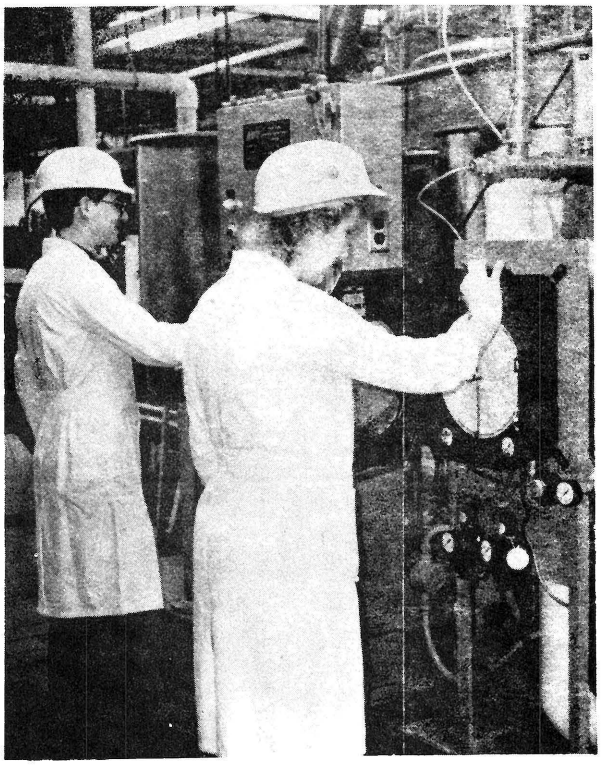
Research Circular 292 November 1987

FOOD PROCESSING & TECHNOLOGY - 1987
A SUMMARY OF RESEARCH



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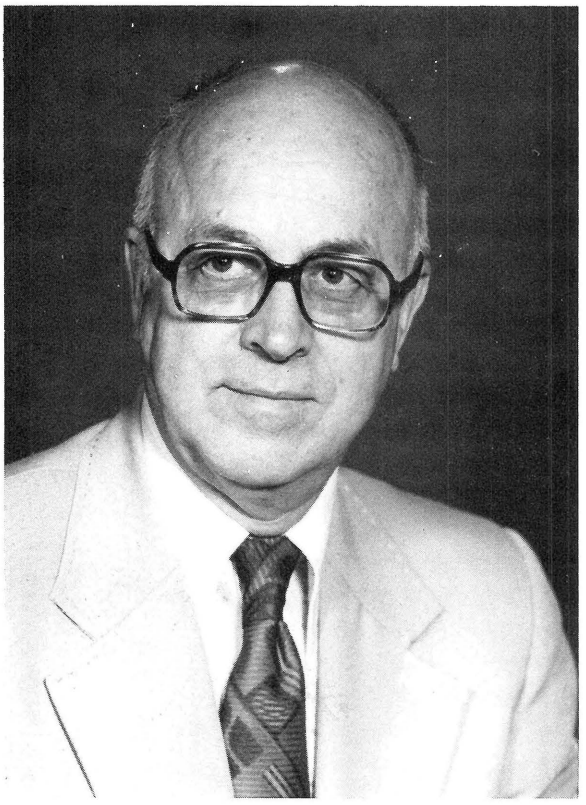

Dedication

This issue is dedicated to Dr. Wilbur A. Gould for his 39 years of devotion and contribution to the Department of Horticulture, The Ohio State University, and the food processing industry.

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TOMATO CULTIVAR EVALUATION: RAW, CANNED, AND JUICE

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INTRODUCTION

Tomatoes continue to be an important Ohio processing crop. Ohio's planted acreage of slightly fewer than 20,000 acres produces more than 400,000 tons. However, this is less than one-half of the tonnage that the state processes. Ohio ranks second to California in volume of processed tomatoes, tomato juice, and tomato products.

This study is concerned primarily with evaluating new tomato cultivars for processing. The research is also directed toward improvement of the quality of the various type products packed from tomatoes. The specific objective of the program is to determine the suitability of Ohio-grown cultivars, developed in the breeding program, for processing.

MATERIALS AND METHODS

The 1984 and 1985 processing project included 31 cultivars in 1984 and 30 cultivars in 1985 grown in replicated plots under acceptable commercial practices at the OARDC Vegetable Crops Branch near Fremont. Each cultivar was machine harvested using a FMC Western Model with little or no sort on the harvester and bulk handled in 400-lb steel bins. Following harvest, the tomatoes were transported by truck (approximately 100 miles) to The Ohio State University Food Processing Pilot Plant at Columbus for processing. All lots were processed within 24 hours following harvest as peeled whole tomatoes, diced tomatoes, and juice.

Evaluation: Twenty field-run tomatoes were randomly selected and used for objective and subjective raw quality evaluation.

- The tomatoes were classified as globe, pear, blocky, or ovate in shape.
- Size was determined by weighing a 20-lb sample, counting the number of tomatoes, and then calculating the number per pound.
- Stem scar length and stylar scar length were measured objectively by determining the average length in inches of each scar.
- Firmness was determined subjectively and rated as soft, puffy, medium, or hard.
- The sample was then prepared for color evaluation using the California Blender system of extraction as follows:
  a. Remove 8.5 lb of tomatoes sampled at random from the lot.
  b. Wash the sample, quarter and stem the fruits.
  c. Place the sample in a blender and cover with blender lid connected to a vacuum source.
  d. Start vacuum and when gauge reaches 27, start blender for 5 seconds.
  e. Stop blender, remove the container without breaking vacuum, turn upside down and shake. Return the container to the blender and blend for 1 minute.
  f. Remove the blender lid, insert 14-mesh wire screen into container, and ladle juice (175 ml) into Agtron color dish.
  g. Adjust Agtron calibration if necessary, close drawer of Agtron, and read tomato color.
- The color was evaluated with the Agtron E-5 instrument with the instrument calibrated at 48. The color reading was taken directly and recorded as such.
- The juice was also measured by the Hunter color difference meter D25 D3A using a standard plastic sample cup, the Hunter TCM value, a, L, and b values were determined and the a/b ratio and TCM index were calculated.
- Percent soluble solids: An Abbe refractometer was used for direct determination of percent soluble solids. The instrument was standardized with distilled water and all readings were converted to 70°F. (For juice the refractive index is also given.)
- pH: The pH was determined by the glass electrode method (Beckman Zeromatic pH Meter), using 10 ml of tomato juice diluted with 90 ml of distilled water.
- Percent total acid as citric: The sample used for pH determination was directly titrated using the following equation:

$$\text{Percent acid} = \frac{(\text{No. of ml of 0.1 N NaOH})\ (.0064)}{10\text{ ml sample}} \times 100$$

The assistance of the following is greatly appreciated: Shari Plimpton, Paul Pak, Jeff Thomas, Wennie Lloyd, George Emerson, Janeen Hahn, Leslie Sipp, Leasia Johnson, Stacey Smolik, Dyi Hou, and Emru Erten

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- Ascorbic acid: Ten ml aliquots of tomato juice were diluted with 90 ml of 1 percent metaphosphoric acid and filtered. A 10 ml aliquot of the filtrate was titrated with 0.2 percent 2,6-dichlorophenolindophenol indicator solution. Milligrams of vitamin C were determined by the following formula:

  Dye factor x ml of dye x 100 = mg vitamin C/100 g
- The sugar/acid ratio (S/A) was calculated by dividing the percent soluble solids by the percent titratable acid.
- Consistency was measured in seconds by effluxing 150 ml of juice at 70°F through the GOSUC consistometer standardized at 32 seconds with water and a 5/64-inch precision bore orifice.

Preparation and processing of the tomato: All tomatoes were prepared for canning by washing, lye peeling (18 percent caustic soda and 0.1 percent Faspeel at 190°F (88°C) for 20 seconds), filling, closing, and processing in a still retort as whole tomatoes. Each lot of whole tomatoes was filled to 10.0-10.5 oz in No. 303 x 406 size fruit enamel tin cans with a 50-grain salt tablet containing 44.5 percent NaCl, 15 percent $CaSO_4H_2O$, 37 percent citric acid, and 3.5 percent $NaHCO_3$, covered with hot juice (190°F) (88°C), and steam flow closed.

Juice was made from each cultivar of tomato by washing, chopping, preheating to 190°-200°F (88°-93°C), extracting using a 0.023-inch screen in a Langsenkamp extractor, high-temperature, short time sterilizing (252°F (122°C), 42 seconds), cooling to 200°F (93°C), filling in 303 x 406 enamel cans, adding a 30-grain NaCl tablet, closing, inverting and holding for 3 minutes, and spin cooling to 100°F (38°C) prior to casing and storing.

Grades were determined in accordance with the U.S. Standards for Grades of Canned Tomatoes and Tomato Juice.

High Pressure Steam Peeling: During the 1985 Tomato Cultivar processing program, 15 cultivars were lye peeled as above and high pressure steam peeled in an Odenberg, K & K Model 5, High Pressure Steam Processor, in order to evaluate their peeling efficiency.

For both peeling methods, 40-lb lots of washed tomatoes were used. The steam peeling method consisted of placing the tomatoes in the pressure vessel, venting the vessel for 3 seconds, pressure steaming at 90 p.s.i. for 24 seconds, venting for 3 seconds, and rotating the vessel to allow dumping of the steamed product. Following the pressurized treatment, the peeled tomatoes were weighed and processed as whole canned tomatoes, as above.

RESULTS AND DISCUSSION

The actual data for each cultivar presented in Tables 1 and 2, by years, indicate some substantial differences between cultivars and differences for the same cultivar between years. The fruit for 1985 were generally smaller and a little more mature than the 1984 samples. Specifically, in 1984 Ohio 7983, 8153, 8290 and 8297 were the best cultivars for whole packed canned tomatoes. For juice, Heinz 2653, Ohio 833, 832, 7912, 8129, 8297, 3025, 3694, and 3734 were excellent in quality. In 1985, Ohio 8245, 8363, 8445, 8448 and OE 3774-1 were evaluated the highest quality for whole canned tomatoes. For juice, Campbell 4135, Ohio 8243, 8431, 8383, 8444, 8448, 8355 and 8297 all produced high quality product.

The pH in 1985 was very high when considering the average from all 30 cultivars, with a value of 4.48. This value was raised because several cultivars had readings above 4.50.

The results of the lye vs. high pressure steam peeling are presented in Table 2 where the grades for both are compared and Table 3 where the peeling efficiencies are compared.

There are significant differences between cultivars when compared within the same peeling system as well as significant differences between the same cultivar for lye and steam peeled fruit. Even though some very significant differences exist, when the averages for the 15 cultivars are compared for lye and steam peeling they are almost identical. In several cases the grades exhibit a reduction in the wholeness for canned whole tomatoes steam peeled. Part of this disparity might be eliminated by adjusting the pressure and exposure on a cultivar basis.

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Table 1. Tomato cultivar evaluation, raw product, canned whole pack, and juice, 1984.

	1	2	3	4	5	6	7	8
Lot No.	Ohio	Ohio	Heinz	Heinz	Campbell	Ohio	Ohio	Ohio
Cultivar	833	832	2653	722	4135	7814	7825	7870
Raw								
Fruit Shape	Globe-Ovate	Ovate-Blocky	Ovate-Pear	Ovate-Pear	Ovate-Blocky	Ovate	Ovate-Pear	Ovate-Blocky
No/lb.	5.8	4.8	7.8	7.6	6.5	7.4	6.8	6.0
Stem Scar	1/4-3/8"	1/4-3/8"	1/4"	1/4"	3/8-1/2"	1/4-3/8"	1/4-3/8"	1/4"
Styler Scar	none	1/8"	none	none	1/8"	none	none	none
Firmness	Hard	Hard-Puffy	Hard	Hard	Hard	Hard-Puffy	Hard-Puffy	Hard
E-5 Pulp Color	31.75	33.25	33.0	34.75	32.75	33.5	34.35	34.75
L	27.33	27.13	28.84	28.44	27.87	28.23	28.65	28.87
a	28.39	26.74	29.78	28.75	28.53	29.98	28.31	29.77
b	12.79	23.26	12.95	12.69	12.72	12.97	12.78	12.70
a/b	2.22	2.29	2.30	2.26	2.24	2.31	2.21	2.34
TCM	66.73	67.62	63.62	64.34	65.55	65.02	63.64	63.73
pH	4.45	4.4	4.34	4.48	4.38	4.35	4.41	4.26
T.A.	.30	.30	.28	.31	.31	.32	.28	.34
S.S.	4.15	4.2	4.78	4.2	4.75	4.7	4.50	4.60
Vit. C	15.49	14.56	17.67	17.40	22.80	17.03	18.42	16.23
Canned								
Dr. Wt (20)	18	15	18	18	17	15	17	15
Wholeness (20)	20	20	20	20	20	20	20	20
Color (30)	28	23	24	23	25	26	23	24
Defects (30)	30	30	28	30	30	30	30	30
Total (100)	91	88	90	88	92	91	90	89
Grade	C	C	B	C	B	C	C	C
Juice								
Viscosity	40.6	36.7	38.7	39.8	37.5	38.0	36.4	38.8
Agtron E-5	36.0	35.75	36.8	42.0	40.3	37.3	38.0	38.82
L	26.17	25.42	26.21	25.93	26.26	26.19	26.3	26.90
a	26.42	26.33	25.58	23.24	24.00	25.04	24.091	25.10
b	13.99	13.51	14.01	13.72	14.30	13.94	14.50	14.39
a/b	1.88	1.94	1.82	1.69	1.67	1.79	1.66	1.74
% S.S	4.9	4.9	4.8	4.7	5.6	4.95	4.9	5.0
pH	4.5	4.5	4.45	4.45	4.3	4.4	4.4	4.43
% T.A.	0.290	0.283	0.290	0.312	0.335	0.328	0.313	0.325
SS/Acid	16.90	17.31	16.59	15.07	16.72	15.09	15.71	15.40
Color (30)	30	30	27	27	26	27	27	28
Consistency (15)	15	14	13	13	13	13	13	14
Defects (15)	15	15	15	15	15	15	15	15
Flavor (40)	40	39.5	37	37	36	36	38	38
Total (100)	100	98.5	92	92	90	91	93	95
Grade	A	A	A	A	A	A	A	A
Viscosity	49.59	57.22	41.30	50.1	42.9	46.70	44.5	46.25
Agtron F	37.5	38.5	38.5	37.25	37.7	33.5	40	40
L	25.56	23.85	25.3	25.2	25.6	25.8	24.5	25.67
A	25.36	23.95	24.75	24.3	24.2	26.95	23.0	23.73
B	13.66	12.42	13.3	13.60	14.0	14.25	13.48	13.74
a/b	1.85	1.92	1.86	1.78	1.22	1.89	1.70	1.72
% S.S.	6.1	6.5	5.6	5.85	6.1	6.05	6.1	6.3
pH	4.43	4.4	4.3	4.325	4.325	4.18	4.275	4.31
% TA	0.364	0.364	0.35	0.35	0.332	0.368	0.371	0.415
SS/Acid	16.76	17.86	15.96	16.85	18.37	16.28	16.34	15.18
Color	29	30	30	30	29	29	28	28
Cons.	15	15	14	14	14	13	13	13
Defects	15	15	15	15	15	15	15	15
Flavor	40	39	40	40	38	38	37	37
Total	99/A	99/A	99/A	96/A	95/A	95/A	93/A	93/A

(continued)

Table 1. Tomato cultivar evaluation, raw product, canned whole pack, and juice, 1984. (continued)

	9	10	11	12	13	14	15	16
Lot No.	Ohio	Ohio	Ohio	Ohio	Ohio	Ohio	Ohio	Ohio
Cultivar	7983	7912	8129	8136	8153	8239	8253	8290
Raw	Pear-	Ovate-		Globe-		Globe-	Ovate-	Globe-
Fruit Shape	Blocky	Blocky	Blocky	Blocky	Blocky	Ovate	Blocky	Ovate
No/lb.	6.9	5.3	7.3	6.0	4.9	6.1	7.5	8.7
Stem Scar	1/4"	1/4-3/8"	1/4-3/8"	1/4"	1/4-3/8"	1/4-3.8"	1/4"	1/4"
Styler Scar	none	none	none	none	none	none	none	none
Firmness	Hard	Hard	Hard-Puffy	Hard	Hard	Hard	Hard	Hard
E-5 Pulp Color	33.75	32.0	35.0	30.0	32.75	33.0	34.25	36.50
L	30.48	27.68	29.41	26.83	28.03	30.23	29.17	29.34
a	30.73	29.76	28.28	30.79	27.26	28.56	28.90	27.64
b	13.81	12.11	12.4	12.34	12.48	13.24	12.61	11.83
a/b	2.22	2.45	2.28	2.49	2.18	2.15	2.29	2.34
TCM	59.87	66.94	62.30	69.21	58.84	60.05	62.86	62.76
pH	4.29	4.35	4.35	4.31	4.4	4.33	4.45	4.43
T.A.	.26	.27	.35	.36	.33	.33	.28	.31
S.S.	4.61	4.30	4.75	4.1	5.25	4.5	4.3	5.0
Vit. C	19.73	21.25	25.48	18.49	19.83	14.87	20.34	17.67
Canned								
Dr. Wt (20)	16	16	16	17	16	15	16	19
Wholeness (20)	20	20	20	20	20	20	20	19
Color (20)	28	22	26	26	28	28	27	28
Defects (20)	30	28	30	30	30	30	30	30
Total (100)	94	86	92	90	94	93	93	96
Grade	A	C	B	B	A	C	A	A
Juice								
Viscosity	41.4	40.2	44.6	43.3	49.0	41.8	85.9	43.6
Agtron E-5	36.0	36.5	36.3	34.5	35.3	38.3	37.5	34.3
L	26.54	25.56	26.38	25.41	26.26	26.36	27.63	26.19
a	25.59	25.41	25.71	26.10	26.21	24.25	24.53	25.57
b	14.06	13.36	13.89	13.23	13.77	13.82	14.48	13.57
a/b	1.82	1.90	1.85	1.97	1.90	1.75	1.69	1.88
% S.S	5.35	4.8	5.6	5.9	5.8	5.0	5.4	5.65
pH	4.43	4.40	4.43	4.5	4.45	4.38	4.48	4.4
% T.A.	0.315	0.284	0.361	0.329	0.316	0.319	0.300	0.300
SS/Acid	16.99	16.94	15.55	17.97	18.39	15.72	18.03	18.89
Color (30)	29	30	30	30	30	27	28	28
Consistency (15)	13	15	14	13	13	13	13	13
Defects (15)	15	15	15	15	15	15	15	15
Flavor (40)	40	40	40	40	40	37	38	38
Total (100)	97	100	99	98	98	92	94	94
Grade	A	A	A	A	A	A	A	A
Viscosity	37.00	44.2	41.3		38.3	45.9	52.9	48.5
Agtron	41.5	34	37.0		36.3	39.3	42.5	37.5
L	24.4	24.5	25.26		25.38	25.29	26.15	25.93
A	22.4	26.4	24.96		23.87	23.79	22.13	23.99
B	12.7	13.1	13.38		13.20	13.40	13.22	13.22
a/b	1.76	2.01	1.86		1.80	1.77	1.67	1.81
% S.S.	5.65	6.1	6.1		5.2	5.8	5.9	5.8
pH	4.3	4.35	4.3		4.4	4.3	4.4	4.5
% TA	0.387	0.370	0.427		0.298	0.366	0.299	0.319
SS/Acid	14.63	16.49	14.30		17.48	15.87	19.79	18.44
Color	28	30	30		28	29	28	28
Cons.	18	15	15		15	14	13	14
Defects	15	15	15		15	15	15	15
Flavor	38	40	40		38	38	38	38
Total	94/A	100/A	100/A		96/A	96/A	94/A	95/A

(continued)

Table 1. Tomato cultivar evaluation, raw product, canned whole pack, and juice, 1984. (continued)

	18	19	20	21	22	23	24	25
Lot No.	Ohio	Ohio	Ohio	Peto	OE	OE	OE	OE
Cultivar	8245	8297	8295	95-43	3604	3642	3025	3029
Raw	Globe-	Globe-	Ovate-	Pear-	Globe-	Ovate-	Ovate-	
Fruit Shape	Blocky	Ovate	Blocky	Blocky	Ovate	Pear	Blocky	Ovate
No/lb.	6.7	5.1	6.2	5.5	5.6	5.5	6.0	5.9
Stem Scar	1/4-3/8"	3/8-1/2"	1/4-3/8"	1/4"	3/8-1/2"	1/4-3/8"	1/4-3/8"	1/4-3/8"
Styler Scar	none	none	none	none	1/8"	none	none	none
Firmness	Hard-Puffy	Hard	Hard	Hard-P	Hard	Hard	Hard	Hard
E-5 Pulp Color	33.0	33.75	32.5	35.5	33.0	37.5	33.5	34.5
L	27.88	28.47	26.37	27.32	28.62	29.13	28.55	32.30
a	28.98	26.19	28.15	26.70	29.49	26.80	29.14	25.29
b	12.97	11.98	11.92	11.84	12.09	11.59	12.33	9.86
a/b	2.23	2.19	2.36	2.25	2.44	2.31	2.36	2.56
TCM	65.48	63.89	69.86	66.93	64.66	63.02	64.53	57.70
pH	4.41	4.35	4.49	4.39	4.32	4.40	4.40	4.4
T.A.	.30	.33	.24	.26	.30	.33	.35	.26
S.S.	4.70	4.8	4.6	4.55	5.8	4.5	4.8	4.4
Vit. C	22.41	19.21	17.78	18.49	25.59	13.69	16.3	18.44
Canned								
Dr. Wt (20)	15	16	15	14	16	15	15	14
Wholeness (20)	20	20	20	20	20	20	20	20
Color (30)	27	29	22	22	25	25	27	29
Defects (30)	30	30	28	30	30	30	30	30
Total (100)	92	95	85	86	92	89	92	93
Grade	C	B	C	C	B	C	C	C
Juice								
Viscosity	53.8	96.4	57.1	45.3	46.6	48.8	45.6	62.9
Agtron	34.3	35.3	34.3	37.3	33.3	37.3	34.3	33.8
L	27.72	26.62	25.17	28.85	26.34	26.70	25.90	26.04
a	26.98	24.73	26.06	24.10	26.34	23.78	25.67	25.33
b	15.03	13.73	13.76	14.03	14.01	13.35	13.82	13.78
a/b	1.79	1.80	1.89	1.71	1.88	1.78	1.85	1.83
% S.S	5.7	5.7	5.3	4.9	5.65	5.25	5.65	5.05
pH	4.3	4.35	4.45	4.33	4.25	4.2	4.28	4.4
% T.A.	0.338	0.280	0.245	0.280	0.348	0.328	0.306	0.306
SS/Acid	16.86	20.36	21.63	17.51	16.24	16.01	18.47	15.51
Color (30)	28	30	30	28	30	30	27	28
Consistency (15)	13	15	13	13	15	15	13	13
Defects (15)	15	15	15	15	15	15	15	15
Flavor (40)	38	40	37	37	40	40	37	37
Total (100)	94	100	95	93	100	100	92	93
Grade	A	A	A	A	A	A	A	A
Viscosity	42.0	48.96	55.56	44.34	43.27	42.72	37.13	50.18
Agtron	36.0	37.3	32.0	38.5	38.0	42.8	36.0	36.5
L	26.10	25.90	24.94	24.73	24.89	24.57	25.13	25.05
A	25.87	23.86	26.83	23.43	23.36	21.54	24.56	24.46
B	14.35	13.43	13.79	13.33	13.02	12.31	13.35	13.51
a/b	1.80	1.78	1.94	1.75	1.79	1.74	1.83	1.81
% S.S.	5.8	5.8	5.5	5.8	5.65	5.85	5.7	5.75
pH	4.3	4.3	4.31	4.3	4.37	4.27	4.35	4.32
% TA	0.342	0.309	0.280	0.326	0.351	0.390	0.334	0.355
SS/Acid	16.99	18.65	19.65	17.91	16.11	15.02	17.10	16.23
Color	30	30	30	29	29	29	30	29
Cons.	13	15	14	15	15	14	15	14
Defects	15	15	15	15	15	15	15	15
Flavor	40	40	38	38	38	38	40	39
Total	98/A	100/A	97/A	97/A	98/A	96/A	100/A	97/A

(continued)

Table 1. Tomato cultivar evaluation, raw product, canned whole pack, and juice, 1984. (continued)

	26	27	28	29	30	31	32
Lot No.	OE	OE	OE	OE	OE	OE	OE
Cultivar	3032	3042	3021	3046	3694	3734	1784
Raw				Globe-			
Fruit Shape	Globe	Blocky	Globe	Ovate	Ovate	Ovate	Pear
No/lb.	6.4	5.3	5.1	7.4	6.2	5.4	8.0
Stem Scar	1/4-3/8"	3/8-1/2"	1/4-3/8"	1/4"	1/4-3/8"	1/4"	1/4"
Styler Scar	1/8"	1/8"	none	none	none	none	none
Firmness	Hard	Hard	Hard	Hard-P.	Hard	Hard-Puffy	Hard
E-5 Pulp Color	42.25	31.25	41.75	42.5	35.75	30.5	35.0
L	29.51	29.99	30.80	29.4	28.43	27.13	31.62
a	22.20	28.93	25.53	21.29	28.80	26.32	25.52
b	12.71	13.42	12.22	12.37	12.28	8.75	8.75
a/b	1.75	2.15	2.09	1.72	2.34	3.01	2.68
TCM	62.47	60.52	58.59	58.94	64.73	69.98	59.29
pH	4.35	4.25	4.25	4.38	4.25	4.38	4.4
T.A.	.25	.31	.35	.31	.29	.29	.31
S.S.	4.2	4.4	5.2	4.4	4.8	5.0	4.25
Vit. C	18.59	15.65	15.26	17.04	20.21	16.67	18.79
Canned							
Dr. Wt (20)	16	17	15	15	16	14	16
Wholeness (20)	18	19	20	20	20	20	20
Color (30)	23	23	26	23	28	26	28
Defects (30)	30	30	30	30	30	30	30
Total (100)	87	89	91	88	94	90	94
Grade	C	C	C	C	A	C	A
Juice							
Viscosity	52.8		43.57	69.6	48.13	53.78	44.98
Agtron E-5	39.8		39.8	37.0	36.5	32.8	34.0
L	26.67		28.55	27.75	25.99	25.04	25.92
a	22.62		23.42	24.46	24.04	26.41	24.60
b	14.10		14.77	14.66	13.63	12.64	13.34
a/b	1.60		1.58	1.66	1.76	2.08	1.84
% S.S	4.65		5.55	4.75	5.4	5.5	4.8
pH	4.43		4.2	4.38	4.38	4.4	4.33
% T.A.	0.255		0.355	0.255	0.325	0.293	0.303
SS/Acid	18.29		15.00	18.67	16.62	18.78	15.84
Color (30)	27		25	26	29.5	30	30
Consistency (15)	13		13	14	14	15	15
Defects (15)	15		15	15	15	15	15
Flavor (40)	37		36	38	38.5	40	40
Total (100)	92		89	88	97	100	100
Grade	A		A	A	A	A	A
Viscosity	39.89	48.04	33.1	46.6	45.9	46.8	88.4
Agtron F	38.5	42.0	46	39.8	38.3	37.5	33.5
L	25.89	25.74	26.14	26.18	24.71	24.17	25.20
A	23.73	22.05	19.59	23.51	24.18	24.72	26.72
B	14.09	13.29	13.86	13.97	13.17	12.14	13.42
a/b	1.68	1.65	1.41	1.68	1.83	2.03	1.98
% S.S.	5.7	5.7	4.25	5.4	5.21	5.70	6.9
pH	4.4	4.23	4.23	4.33	4.28	4.37	4.35
% TA	0.319	0.364	0.301	0.332	0.390	0.287	0.428
SS/Acid	17.90	15.69	14.13	16.31	13.40	19.89	16.13
Color	28	28	24.5	26	30	30	30
Cons.	15	15	10	15	15	15	13
Defects	15	15	15	15	15	15	15
Flavor	37	38	30	40	40	40	40
Total	95/A	96/A	79.5/C	96/A	100/A	100/A	98/A

Table 2. Tomato cultivar evaluation, raw product, canned whole, and juice, 1985.

	1	2	3	4	5	6	7	8	9	10
Lot No.	Heinz	Ohio	Ohio	Ohio	Ohio	Campbell	Ohio	Ohio	Ohio	Ohio
Cultivar	2653	8441	8842	8449	8492	4135	832	7814	7983	8129
Raw										
Fruit Shape	Globe	Globe	Globe	Blocky	Blocky	Blocky	Globe	Globe	Blocky	Ovate
No/lb.	10	9	9	7	8	8	6	6	6	8
Stem Scar	<1/4"	<1/4"	<1/4"	1/4-3/8"	<1/4"	<1/4"	3/8-1/2"	3/8-1/2"	3/8-1/2"	1/4-3/8"
Styler Scar	1/8"	1/8"	1/8"	1/8"	1/8"	1/8"	1/4"	1/8"	1/4"	1/4"
Firmness	Soft	Soft	Soft	Hard	Soft	Hard	Soft	Soft	Soft	Soft
E-5 Pulp Color	38.5	41.5	38.5	39	36	34	29	33	34	36
L	27.50	28.45	27.78	24.87	27.17	26.01	24.78	26.16	25.36	29.39
a	26.51	25.26	27.31	24.96	28.57	28.09	31.58	29.86	30.25	33.85
b	12.25	14.50	13.85	11.35	13.42	12.73	12.49	13.22	12.25	12.26
a/b	2.17	1.55	1.98	2.20	2.12	2.21	2.53	2.25	2.47	2.76
TCM	66.02	60.89	64.21	73.18	66.61	70.05	75.07	69.89	73.11	63.99
pH	4.50	4.57	4.8	4.55	4.40	4.34	4.37	4.30	4.40	4.35
T.A.	.34	.31	.31	.29	.39	.35	.36	.32	.29	.29
S.S.	4.1	4.4	4.8	4.1	4.3	4.0	3.7	4.8	4.3	5.1
Vit. C	16.78	17.05	18.15	13.48	11.04	14.21	22.62	19.43	14.79	13.79
Canned										
Dr. Wt	16	17	15	16	15	14		15	16	14
Wholeness	19	18	20	19	19	20		19	19	19
Color	27	27	28	27	26	28		27	27	27
Defects	29	28	29	28	28	29		29	28	29
Total	91	90	92	90	88	91		90	90	89
Grade	A	A	C	A	C	C		C	A	C
Juice										
Viscosity	35.75	37.31	39.05	37.34	37.02	38.18	41.18		46.97	42.50
Agtron E-5	38	41	36.5	35	36	35	34	36.5	36	34
L	27.60	27.29	27.16	26.44	27.21	26.40	25.51	24.71	25.27	25.33
a	27.75	25.35	27.66	28.54	28.26	27.80	29.39	25.53	27.01	28.68
b	15.31	15.74	15.57	14.92	15.08	14.65	13.96	13.69	14.35	13.39
a/b	1.81	1.61	1.77	1.91	1.88	1.90	2.11	1.87	1.89	2.14
% S.S.	4.7	4.8	5.0	4.6	4.7	4.8	5.2	4.5	4.2	5.0
pH	4.30	4.37	4.31	4.4	4.23	4.55	4.49	4.7	4.33	4.4
% T.A.	.51	.33	.34	.30	.42	.27	.32	.23	.30	.31
SS/Acid	9.22	14.62	14.72	15.18	11.10	17.80	16.51	20.01	13.85	16.13
Color	27	27	28	28	28	29			28	28
Consistency	14	13	14	13	14	15			14	14
Defects	15	14	15	15	15	14			14	15
Flavor	36	35	38	37	35	38			38	37
Total	92	89	95	93	92	96			94	94
Grade	A	A	A	A	A	A			A	A
Steam Pealed										
Dr. Wt				19		15		19	15	
Wholeness				17		19		18	19	
Color				27		26		29	28	
Defects				28		27		29	29	
Total				91		87		95	91	
Grade				A		C		A	C	

(continued)

Table 2. Tomato cultivar evaluation, raw product, canned whole, and juice, 1985 (continued).

	11	12	13	14	15	16	17	18	19	20
Lot No.	Ohio	Ohio	Ohio	Ohio	OE	Ohio	Ohio	Ohio	Ohio	Ohio
Cultivar	8243	8425	8431	8358	3604	8363	8383	8438	8439	8444
Raw										
Fruit Shape	Blocky	Globe	Blocky	Globe	Globe	Blocky	Globe	Globe	Blocky	Blocky
No/lb.	7	7	7	6	6	8	7	6	5	8
Stem Scar	1/4-3/8"	<1/4"	<1/4"	3/8-1/2"	1/4-3/8"	<1/4"	1/4-3/8"	1/4-3/8"	1/4-3/8"	<1/4"
Styler Scar	1/8"	1/8"	1/8"	3/8"	1/8"	1/8"	1/8"	1/8"	1/8"	none
Firmness	Soft	Soft	Hard	Soft	Puffy	Soft	Soft	Soft	Soft	Soft
E-5 Pulp Color	34	35.5	30.5	38.5	33	31.5	32.5	29	31.5	32
L	28.24	26.41	28.00	32.48	25.96	27.22	26.17	24.59	28.09	25.45
a	29.83	30.36	31.41	33.56	29.09	31.52	29.57	30.76	31.23	29.72
b	13.35	12.45	13.07	14.15	12.73	13.84	12.57	12.20	14.60	12.57
a/b	2.24	2.44	2.40	2.38	2.29	2.28	2.35	2.52	2.14	2.37
TCM	64.66	70.02	65.94	56.72	71.03	67.28	70.35	75.62	64.50	72.38
pH	4.4	4.41	4.30	4.34	4.30	4.20	4.19	4.35	4.71	4.5
T.A.	.27	.32	.37	.29	.31	.32	.35	.31	.28	.32
S.S.	4.5	4.6	4.6	5.20	3.95	4.20	4.40	4.70	4.60	4.10
Vit. C	15.66	17.69	16.82	13.05	11.02	18.85	17.98	16.82	21.66	17.08
Canned										
Dr. Wt	17	17	16	16		18	15	16	16	17
Wholeness	19	20	19	19		19	20	20	19	18
Color	28	29	29	27		29	29	28	28	28
Defects	29	29	29	29		29	29	29	29	29
Total	93	95	93	91		95	93	93	92	92
Grade	A	A	A	A		A	C	A	A	A
Juice										
Viscosity	41.24	45.21	37.47	39.18	36.63	43.16	40.35	39.55	40.63	38.05
Agtron E-5	35	34	35	36	35.5	33	35	33	36	35.5
L	26.17	26.39	26.53	26.26	25.71	25.38	25.79	24.51	26.08	26.27
a	28.82	29.20	29.37	29.06	27.74	28.97	29.07	29.11	27.98	29.12
b	14.65	14.69	14.86	14.56	14.15	14.19	14.83	13.77	14.59	14.85
a/b	1.97	1.99	1.98	2.00	1.96	2.04	1.96	2.12	1.92	1.95
% S.S.	5.0	4.6	5.4	5.4	4.2	5.00	5.30	5.0	4.6	4.8
pH	4.4	4.3	4.21	4.53	4.2	4.07	4.13	4.4	4.7	4.6
% T.A.	.30	.44	.39	1.54	.32	.36	.40	.30	.25	.29
SS/Acid	16.96	10.58	14.03	3.49	13.40	14.08	13.18	16.99	18.4	16.55
Color	29	28	29	28		28	30	28	27	29
Consistency	15	14	15	14		14	15	14	14	15
Defects	15	15	15	15		15	14	15	14	15
Flavor	39	37	29	38		38	39	38	36	39
Total	98	94	98	95		95	98	95	91	98
Grade	A	A	A	A		A	A	A	A	A
Steam Pealed										
Dr. Wt	18	20	17	15						16
Wholeness	18	17	19	20						18
Color	29	28	28	29						28
Defects	29	29	29	30						29
Total	94	94	94	94						91
Grade	A	A	A	C						A

Table 2. Tomato cultivar evaluation, raw product, canned whole, and juice, 1985 (continued).

	21	22	23	24	25	26	27	28	29	30
Lot No.	Ohio	Ohio	Ohio	Ohio	Ohio	OE	Ohio	Ohio	Ohio	Ohio
Cultivar	8445	8446	8448	8460	8477	3774-1	7870	8239	8355	8297
Raw										
Fruit Shape	Globe	Globe	Globe	Blocky	Globe	Blocky	Globe	Blocky	Globe	Globe
No/lb.	5	8	8	9	6	6	8	7	7	6
Stem Scar	1/4-3/8"	<1/4"	1/4-3/8"	1/4-3/8"	1/4-3/8"	1/4-3/8"	<1/4"	<1/4"	1/4-3/8"	3/8-1/2"
Styler Scar	1/8"	1/8"	1/8"	1/8"	1/8"	1/8"	1/8"	1/8"	1/8"	1/8"
Firmness	Soft	Hard	Soft	Soft	Soft	Soft	Soft	Soft	Soft	Hard
E-5 Pulp Color	31	31.5	32	32	30	32	31	31	31	33
L	24.98	27.10	26.64	27.06	24.42	25.48	25.00	25.49	26.28	28.47
a	30.86	31.48	31.20	31.36	30.96	30.25	30.05	30.58	30.92	26.19
b	12.63	13.61	13.02	13.64	11.79	12.61	12.46	13.15	12.74	11.98
a/b	2.45	2.31	2.40	2.30	2.61	2.40	2.41	2.33	2.43	2.19
TCM	74.12	67.75	69.28	67.79	76.46	72.47	73.89	72.10	70.38	63.89
pH	4.65	4.60	4.53	4.63	4.67	4.63	4.65	4.62	4.70	4.35
T.A.	.24	.29	.26	.27	.30	.28	.25	.26	.28	.33
S.S.	4.10	4.60	4.90	4.35	4.50	4.5	4.15	4.45	4.9	4.8
Vit. C	19.99	22.07	16.66	22.20	17.02	17.02	18.13	19.24	21.46	19.21
Canned										
Dr. Wt	17	15	16	17	17	17	16	17	15	14
Wholeness	20	20	19	18	19	19	19	18	19	20
Color	29	28	30	29	27	28	28	28	28	28
Defects	30	30	30	28	29	30	29	28	28	28
Total	96	93	95	92	92	94	92	91	90	90
Grade	A	C	A	A	A	A	A	A	C	C
Juice										
Viscosity	43.6	38.24	35.18	36.31	38.51	37.62	36.67	35.66	39.27	36.82
Agtron E-5	34.3	36	34.5	38	36	34	35	35	34	34
L	26.19	26.27	26.54	26.27	25.70	25.93	25.55	25.66	26.28	28.65
a	25.57	28.48	28.80	28.20	29.51	29.21	28.47	28.89	28.54	28.81
b	13.57	14.44	14.70	14.68	14.02	14.55	14.36	14.59	14.43	14.42
a/b	1.88	1.98	1.96	1.92	2.10	2.01	1.98	1.98	1.98	1.96
% S.S.	5.65	4.9	4.5	5.2	5.25	5.5	4.9	5.0	5.3	5.2
pH	4.4	4.7	4.49	4.40	4.45	4.50	4.42	4.38	4.41	4.39
% T.A.	.30	.31	1.25	.34	.40	.35	.35	.32	.37	.36
SS/Acid	18.84	15.81	3.6	15.29	13.13	15.71	14.14	15.72	14.19	14.16
Color	28	28	29	28	28	28	27	28	28	28
Consistency	14	14	14	14	14	14	14	14	15	15
Defects	13	13	15	15	14	14	15	15	15	15
Flavor	35	35	38	38	37	38	38	37	39	38
Total	90	90	96	95	93	94	94	94	97	96
Grade	A	A	A	A	A					
Steam Pealed										
Dr. Wt			16	16			16	16		
Wholeness			18	17			16	19		
Color			29	28			28	29		
Defects			29	29			28	29		
Total			92	90			88	93		
Grade			A	A			B	C		

Table 3. Tomato cultuvar evaluation.
Lye peeled vs. high-pressure steam peeled for 1985 cultivars.

	Lye Peeler				Steam Peeler			
Cultivar No.	Raw Weight	Peeled Weight	Peel Weight	% Peel Weight	Raw Weight	Peeled Weight	Peel Weight	% Peel Weight
4	40 lb	32.00 lb	8.00 lb	20.00 %	40 lb	30.00 lb	10.00 lb	25.00 %
6	40	33.50	6.50	16.25	40	32.50	7.50	18.75
8	40	32.00	8.00	20.00	40	27.00	13.00	32.50
9	40	33.00	7.00	17.50	40	34.00	6.00	15.00
11	40	31.00	9.00	22.50	40	32.00	8.00	20.00
12	40	33.00	7.00	17.50	40	28.25	11.75	29.40
13	40	28.75	11.25	28.10	40	33.00	7.00	17.50
14	40	33.25	6.75	16.90	40	35.00	5.00	12.50
20	40	31.75	8.25	20.60	40	31.50	8.50	21.25
23	40	33.00	7.00	17.50	40	30.50	9.50	23.75
24	40	25.50	14.50	36.25	40	32.25	7.75	19.40
27	40	27.75	12.25	30.60	40	29.25	10.75	26.90
28	40	23.50	16.50	41.25	40	31.25	8.75	21.90
29	40	33.25	6.75	16.90	40	31.00	9.00	22.50
30	40	33.25	6.75	16.90	40	30.00	10.00	25.00
Average	40	30.97	9.03	22.57	40	31.17	8.83	22.07

FURTHER STUDIES ON COLOR EVALUATION OF POTATO CHIPS

by

Wilbur A. Gould[1]

INTRODUCTION

Color of potato chips has been under investigation for the past several years (1). The Agtron color instrument has proven to be a versatile objective instrument for chip color evaluation (2, 3, 4). However, uniformity of readings has plagued the user. Variations in chip size, amount of defective chips in the sample, and use of the instrument are the objectives of the present study.

MATERIALS AND METHODS

Chip samples were those from the variety evaluation plots — state and national — and commercial samples. Over 750 samples were presented to the Agtron for color scores during the past two years. The Model E5F Agtron and the M30 Agtron were used in this study.

PROCEDURE

Both Agtrons were standardized using Black disc at 0 and 90 and white disc at 90. The Agtron E5F reads color as the ratio of 546/811 nm (green/infrared ratio) and the Agtron M30 reads color as the ratio of 546/640 nm (green/visible red ratio). The chips were whole and crushed as shown in Table 1. The defective chips were those chips with darkened areas greater than 1/4 inch. These darkened defective areas were broken off and removed from the sample for the defect-free chips.

PRESENTATION OF RESULTS

The data in Table 1 show the Agtron E5F values for various sizes (whole and crushed chips). These data indicate as much as an 18.7 point depression in the color values depending on the size of the chip. The data also point out the greater color range for the larger size chip (5.2) versus .05 color range for the smaller size pieces. The crushing of the chips makes the color evaluation a destructive color test, but one can expect greater uniformity in color readings by crushing the sample. It should be pointed out that these color values were obtained without removing any of the defective chips which accounted for as muchas 20 percent of the total amount.

Defects in potato chips may come from bruised, sprouts, or decayed areas not removed in the trimming and peeling operation. Other defective areas may be from the frying operation when burned areas may develop, generally due to masked bruised areas. Defective areas are defined by the industry as minor or major defects. Minor defects are "discolored appearance which adversely affects the chip to a noticeable degree, that is, 1/4 square inch or less, or a blemished areas including peel, internal discoloration or harmless extraneous materials which adversely affects the chip; that is, 1/4 square inch or less." Major defect is a "discolored appearance which adversely affects the chip to a degree that is objectionable, that is, more than 1/4 square inch in area or a blemished areas including peel, internal discoloration or harmless material which seriously affects the chip; that is, more than 1/4 square inch in area." The percentage of defective (minor or major) chips is determined on each sample for arriving at product quality levels. (See Table 2).

Several samples of chips were evaluated with and without defects. The data indicate that Agtron color scores can be depressed up to 7 points if all chips have defects. One would expect for typical commercial chips meeting the defect tolerance in Table 2 that an Agtron color depression could be lowered by 4 points on uncrushed chips.

Table 1. The effect of chip size on agtron color

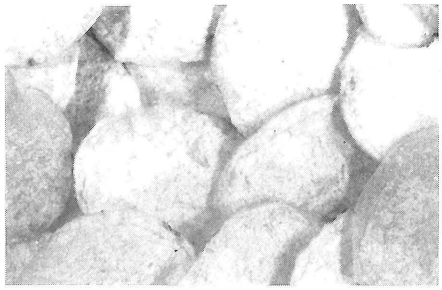
Chip size in mm	Approximate size in inches	Agrton Values
Whole chip	2 inches or larger	60.5 ± 5.20
20 X 20 mm	1 inch	60.1 ± 5.00
10 X 10 mm	½ sq. in.	56.6 ± 1.60
5 X 5 mm	3/8 sq. in.	52.5 ± 0.40
4 X 3 mm	1/4 sq. in.	49.9 ± 0.25
1 X 5 mm	Less than 1/8 sq. in.	47.0 ± 0.05

Table 2. Relationship of percntage of defects to quality levels of chips.

Quality levels	Maximum % Defects as Minor	Major
1 Excellent	0 - 5	0 - 3
2 Good	6 - 10	4 - 5
3 Fair	11 - 15	6 - 8
4 Poor	16 - 20	9 - 12
5 Off	Over 20	Over 12

[1]Professor Emeritus

Table 3. Relationship of color score to agtron values.

Chip Sample	Color Scores	Agtron M-30 Red Value	Agtron E-5F Ratio Color
	1	65 & higher	61 - 70
	2	55 - 64	50 - 60
	3	45 - 54	39 - 49
	4	35 - 44	28 - 38
	5	Less than 34	less than 28

A third factor affecting uniformity of Agtron readings has been the drifting of the Agtron during the time the sample is placed in the instrument and the time of reading. This is particularly true when using the E5F as the sample is placed inside the instrument and some heat is generated from the light source. No effect was noted if the sample was read within 8 seconds after placing the sample in the instrument. If left in the instrument for up to 3 minutes the readings were depressed as much as three points.

RECOMMENDATIONS

The recommended procedures:

1. Standardize instrument using black disc 0 and 90 and white disc at 90.
2. Select a representative sample and use 100 grams of uncrushed uniform size chips.
3. Present the sample to the instrument and read the Agtron color value within 8 seconds.
4. Remove the sample from the instrument and remove all the defective chips.
5. Place 100 grams of defect-free chips in the Agtron color cup and present to the instrument for the true color value.

The reading in #3. above is the defect reading and reading in #5. above is the color reading. (Note: data are being developed for translating the Agtron defect reading to actual defect score.) The color reading is interpreted as color score according to the data in Table 3 and the color charts 1 through 5.

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NEW USES FOR CANNED DICED TOMATOES

by

Wilbur A. Gould and Jackie Caplinger[1]

INTRODUCTION

Canned diced tomatoes were first processed in the late 1970's for secondary use in soups, casseroles, pizza toppings, and salads. The hors d'oeuvres and gourmet market has been developing rapidly and new products are on the increase. This study was concerned with the development of a batter and breaded hors d'oeuvres using canned diced tomatoes.

REVIEW OF LITERATURE

When coating food with batter and breading, a thin, even, and unbroken covering that will adhere is desired. Adhesion is the chemical and physical binding of a coating both to itself and to the food product it coats (6).

The coating should both adhere to the product and maintain moisture in the product while not absorbing moisture from the product. A liquid stabilizer can retard moisture loss and has the ability to make breading adhere tightly to odd-shaped pieces (2). Banner (3) reported adjustments can also be made to increase moisture, to increase batter and breading pickup, and to reduce fat retention during frying.

The coated product should have a crispy, crunchy, golden brown outside, and a soft, moist, flavor-packed inside. Johnson (4) has published a process that will achieve crispness by combining tempura with Japanese batter. Other breadings are available for mass-produced frozen foods as reported by Angell (1).

MATERIALS AND METHODS

All tomatoes used in this study were obtained from The Ohio State University Vegetable Crops Branch, OARDC, Fremont, Ohio. The cultivars were grown under accepted cultural practices for this region. They were mechanically harvested, and then transported to The Ohio State University Pilot Processing Plant in Columbus, Ohio. At the plant, the tomatoes were prepared for canning by washing, lye peeling (18 percent caustic soda and 0.1 percent Faspeel at 190°F [88°C] for 20 seconds), dicing (1/2" x 1/2" x 3/8") with an Urschel GK dicer, filling, closing, and processing in a still retort (220°F -20 minutes). Each lot of tomatoes was filled in 303 x 406 size fruit enamel tin cans with a 50-grain salt tablet containing 44.5 percent NaCl, 15 percent $CaSO_4$ H_2O, 37 percent citric acid, and 3.5 percent $NaHCO_3$ and covered with hot juice (190°F [88°C]) and steam flow closed. The cans were then cooled, cased, and stored until needed.

TOMATO HORS D'OEUVRES FORMULATION

All tomatoes hors d'oeuvres were made by molding canned diced tomatoes into a ball. The canned tomatoes were drained through a #12 screen and all excess liquid removed. The liquid was then used to mix the batter. The solid pieces of the tomato were scooped using either #70 or #100 size food server scoop and then gently pressed by hand until firm. This tomato core (ball) was submerged in a commercial batter and then coated (once or twice) with Japanese style bread crumbs. The coated product was allowed to set and stabilize approximately 5 minutes then deep fried for approximately 1 1/2 minutes, or until golden brown. The oil was maintained at 350°F in a batch type fryer. After frying, the balls were drained for 5 minutes. The finished hors d'oeuvres were placed on food trays and quick frozen. After freezing, the balls were packaged in aluminum foil trays with clear plastic lids. Each 3" x 5" x 2" tray contained 15 hors d'oeuvres. Similar samples analyzed in the "fresh" state were formed and then served freshly prepared, not frozen. Frozen balls were reheated prior to serving in either a Frigidaire "Super" electric oven or a Litton Industries microwave oven at 400°F ±25 for 18 minutes and 150 seconds ± 15, respectively.

SENSORY EVALUATION

Sensory panels were used for evaluating hors-d'oeuvres. All of the evaluations were conducted in the Food Processing and Technology Flavor Laboratory at The Ohio State University, Columbus, Ohio. The panels were comprised of Food Processing and Technology students and faculty members with prior panel experience. For each panel, samples were presented to judges on 4-inch paper plates with the samples in a triangular arrangement and coded with random letters. Triangular and hedonic scoring systems were used in the panel evaluations.

OBJECTIVE EVALUATION

The hors d'oeuvres were evaluated for batter and breading pickup (gross and net), oil absorption, and yield.

Percent gross pickup was determined as the difference in raw and breaded weights divided by the breaded weight multiplied by 100.

Percent net pickup was determined as the difference in raw and post-fry weights divided by the post-fry weight multiplied by 100.

Percent yield is defined as the weight of finished product divided by the weight of raw tomato multiplied by 100 (6).

[1]Professor Emeritus and Graduate Student

RESULTS AND DISCUSSION

Three commercially battered and breaded vegetable hors d'oeuvres other than tomato were obtained from local groceries and weighed to determine the average size and weight of the core material and of the coated product. The data in Table 1 present the various parameters measured for these three products. Each package contained approximately 25 pieces of bite-sized coated vegetables. These data provided a target size and weight for the tomato product.

Canned diced tomatoes were scooped using food server scoops (melon) and the tomato meat gently molded into a round ball-like shape. The #100 size scoop produced a core size most like those of the commercial hors d'oeuvres (approximate average weight of 8.5 grams). The #70 scoop yielded a core that averaged over 50 percent more weight than the #100 scoop. The juice drained from the can was used to mix the batter. Two cans (303 x 406) of tomatoes (32 ounce) yield 1 can (16 ounce) of juice and enough tomato meat to form 43 of the #100 cores or 30 of the #70 cores.

When the juice drained from the cans of diced tomatoes was used instead of water in the formulation, the viscosity of the batter fluctuated depending on the solids content of the juice. The liquid portion of the batter formulation had to be adjusted using water-juice combinations to compensate for the variability of the solids content of the juices. High solid juices resulted in high viscosity batters. The higher viscosity (thicker) batter resulted in a higher pickup of breading.

Pickup is a term which refers to the amount of batter and breading that a product core will collect and retain through processing. Pickup offers the processor an opportunity to increase the pounds of finished product output in relation to the pounds of raw material input.

Core size and structure influence pickup. Batter viscosity and breading particle size also affect pickup. The amount of pickup can be increased two-fold, or more, by double-coating the core. The #70 core had a mean weight of 18.3 grams when single-coated and a mean weight of 29.9 grams after double coating. This shows a greater increase in pickup of coating material. The #100 core had a mean weight of 10.8 grams when single-coated and a mean weight of 24.7 grams after double-coating. This is more than a two-fold increase in the amount of batter and breading picked up.

The net percent pickup of the product takes into account the batter and breading lost as well as the oil absorbed during the frying process. Data in Table 2 show the oil absorption values ranging from 9.7 grams to 10.4 grams for the #100 core to 12.1 grams for #70 core.

The percent net pickup for the #70 product was 15.6 percent when single coated and 50.8 percent when double coated. The #100 hors d'oeuvres had a percent net pickup of 5.7 percent when single coated and 63.0 percent when double coated. For both sizes, the percent net pickup was greater than 50 percent when coated twice.

Table 2. Relationship of core size and dip practice on core weights, batter and breaded weights, recent pickup, percent yield, and percent oil absorbtion of tomato hor d'oeuvers.

Measured Attribute	#70 Core Size		#100 Core size	
	Dip 1	Dip 2	Dip 1	Dip 2
Core wt. (g)	13.5	13.1	8.4	8.4
Battered and Breaded wt. (g)	18.3	29.9	10.8	24.7
% Gross Pickup	26.2	55.1	22.2	66.0
% Net Pickup	15.6	50.8	5.7	63.0
% Yield	118.5	203.1	106.0	270.2
% Oil Absorption	12.1	12.2	9.7	10.4

The percent yield of the product is useful in several ways. One use is in the determination of product output versus raw commodity input. In this study, percent yield was calculated by dividing the finished product weight by the raw tomato weight and multiplying by 100. This value gives an indication of return. The single coated core had a 118.5 percent yield. This means there was an 18.5 percent gain in weight by the time the core was finally processed. The double coated core resulted in a 203.1 percent yield. This shows that double coating the #70 core increases the output weight by 103.1 percent or a finished product yield that is increased 5.6 times that of the single coated core. The #100 cores yielded 106.0 percent when single coated or a pickup of 6.0 percent in weight, just due to the coating process. The double coated cores had a 270.2 percent yield. This shows a 170.2 percent increase in core weight just due to the coating process. Double coating the #100 size cores enables the processor to increase the percent yield by a factor of 28.4.

Table 1. Relationship of representative samples of commercially coated hors d'oeuvers vegetables (average of 25 samples).

Vegetable	Average wt. of vegetable (g)	Average wt. of core (g)	% Gross Pickup	% Yield (Calc.,
Mushroom	9.6	7.5	21.1	126.8
Cauliflower	8.5	6.2	27.3	137.6
Zucchini	10.2	7.8	23.9	131.4

GENERAL DISCUSSION

The tomato lends itself to the molding or formulation of cores for coating quite easily. The food server scoop was found to yield a quite uniform core and to be rather simple in technique.

Coating materials could be adjusted to achieve the optimum effect. The liquid portion of the batter formulation must be adjusted depending on the solids of the tomato juice used. Spices and seasonings incorporated in the batter can be adjusted to personal preference. Moisture in the tomato presented no difficulties in coating adhesion. Japanese style bread crumbs result in a product with a unique texture and color. This type of crumb coated quite well and gave good pickup results but must be continually sifted to maintain uniformity.

Pickup of coating materials on the tomato core can be altered by formulation. Gross pickup increases as batter thickness increases. Pickup and finished product weight can be doubled by coating the tomato core twice. The #100 size core, single coated, most resembles those characteristics of commercial coated vegetable hors d'oeuvres.

Sensory data indicate that panelists were unable to distinguish between the microwave and the conventional methods of reheating. This adds versatility to the product and convenience for the consumer.

Using diced canned tomatoes for core formulation allows for secondary processing. Sensory evaluation was conducted to determine if any desirable characteristics would be sacrificed by secondary processing. Freshly prepared hors d'oeuvres formed from unprocessed diced tomatoes were found to be equal in preference to frozen reheated hors d'oeuvres formed from the same core material. In a comparison of fresh product with frozen reheated product formed from canned diced tomatoes, the freshly prepared hors d'oeuvres were preferred.

Freshly prepared hors d'oeuvres using canned diced tomatoes were found to be preferred to those made from unprocessed diced tomatoes.

For this product to compete with other coated vegetables hors d'oeuvres it would have to be marketed frozen, and then reheated by the consumer.

RECOMMENDATIONS

The following recommendations are made to preserve the integrity of the product and to enhance its versatility:

1. Gross pickup at no time should exceed 30 percent. This ensures that the main portion of the hors d'oeuvre is tomato and not coating.
2. Seasonings of various quantities and types can be incorporated into the formulation, whether through the canning process or in the batter, to cover a wide spectrum of flavors depending on cultural preferences.

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EVALUATION OF THREE CULTIVARS OF DRY BEANS IN A CORN-BEAN BLEND UNDERGOING LOW-SHEAR EXTRUSION PROCESSING

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INTRODUCTION

The world population will increase to an estimated 6.35 billion by the year 2000. Ninety percent of this increase will be in the world's poorest countries (Barney, 1980). Because of this projected rapid increase in population, research must be directed toward developing new food products that are good sources of inexpensive, high-quality protein.

Cereals supply energy mainly in the form of carbohydrates. They also contain approximately 6 to 14 percent protein, depending upon the cultivar of grain, its growing climate, and the cultural practices employed. However, cereal proteins are usually deficient in one or more essential amino acids, primarily lysine. This deficiency results in a reduction of cereal protein quality (Whitney and Hamilton, 1981; Harper, 1979b).

A deficiency in essential amino acids can be alleviated in several ways. The cereal can be fortified with the essential amino acid that is lacking (Jansen, et al., 1978), it can be fortified with higher quality protein sources such as casein (Kon and Wagner, 1979; Kon and Dunlap, 1977) or Non-Fat Dry Milk (NFDM) (Harper, 1979b), or it can be combined with oilseeds or legumes, which are rich in lysine, but deficient in metionine (Molina, et al., 1983; Lorenz, et al., 1980; Bressani, et al., 1978; Aguilera and Kosikowski, 1976; Conway and Anderson, 1973).

This complimentary combination of cereal and legume proteins has been a staple of the diet of Latin Americans for centuries. A ratio of approximately 70 percent corn and 30 percent bean by weight provides a proper balance of amino acids obtained (Bressani and Elias, 1974).

In this study scientists manufacture a snack food product by low-shear extrusion processing that provides high-quality proteins, vitamins, minerals, and good storage stability. The proposed food product will be formulated from blends of corn and one of three cultivars of *Phaseolus vulgaris* (dry beans). Each corn-legume blend will be evaluated on its extrusion performance and its organoleptic acceptability.

The product will be a formed pellet dried to a moisture content of 10-14 percent. It can be puffed by frying in hot oil, thus adding calorie density. Because of its nutritional value and high palatability, this food product could be used to supplement the diets of school children and others.

[1]Pilot Plant Supervisor and Professor Emeritus, respectively, Department of Horticulture, OSU.

MATERIALS AND METHODS

Materials. Whole dry beans (*P. vulgaris* L.) were provided by the Asgrow Seed Co. (Kalamazoo, MI). The three cultivars used in this study were Dark Red kidney beans (cv. Montcalm), Navy beans (cv. Midland), and Pinto beans (cv. Fiesta). Degermed No. 2 yellow corn meal was provided by the Wyandotte Popcorn Co. (Marion, OH).

The beans and corn were frozen and subsequently milled through a 1 mm screen on a Fitzpatrick Comminuting Machine, Model D (W. Fitzpatrick Co., Chicago, IL). The prepared flours were combined in a ratio of 70 percent corn flour to 30 percent bean flour. Each batch was blended for 10 minutes in a Hobart, Model A-200-FD mixer (the Hobart Mfg. Co., Troy, OH). Each of the blends was double-sealed in plastic bags and then stored at about -30°C until needed for processing (approximately one week). Prior to extrusion, batches were remixed in a Mapimpianti Ribbon Blender (Mapa, Inc., Lancaster, PA) for 10 additional minutes.

Processing. Each of the blends was processed on a Mapimpianti Low Shear Extrusion System, Model GF-20 (Mapa, Inc., Lancaster, PA). The GF-20 was equipped with a No. 3 predie and screen, and a No. 90506 nine-orifice slitted die. Initial feed moistures ranged between 13-15 percent, while initial dough moistures were adjusted to 29-31 percent. The extruder profiles used are illustrated in Table 1.

Other extrusion parameters, such as F-screw (forming screw) speed, and barrel and screw cooling, were adjusted to maintain uniform flow at the die. Knife speed was

Table 1. Mapimpianti GF-20 low-shear extrusion system operating Profile.

Parameter	Low (1)	Medium (2)	High (3)
Feed Screw (RPM)	19	19	19
G-Screw (RPM)	50	50	50
F-Screw (RPM)	100	100	100
1st Heating Zone (°C)	60	60	70
2nd Heating Zone (°C)	80	80	80
3rd Heating Zone (°C)	80	90	100
4th Heating Zone (°C)	90	100	110

adjusted to obtain uniform pellets approximately 1 inch square. Predrier temperature was maintained at 73°C ±5°C. The extrudate was than dried in a Mapimpianti Static Drier for 10 hours at 55°C and 78 percent relative humidity. The pellets were then transported to the food processing pilot plant at The Ohio State University (Columbus, OH). There they were finish fried in a General Electric, Model HK3 basket fryer (General Electric Corp., Chicago Heights, IL) at 204°C for about 15 seconds.

Expansion Ratio. Expansion was determined using a method described by Sadel (1985). The expansion ratio of the fried pellets was determined by taking the ratio between the bulk densities of the extruded pellets and the fried product. The bulk densities of the pellets and the fried/expanded product were measured in a 1,000 ml volumetric box. The net weight of the extrudates was determined after the box had been firmly shaken to settle the volume.

Color. The color of the fried product was measured on an Agtron, Model E5-F (Magnuson Engineers, Inc., San Jose, CA) using a red to green ratio. The procedure outlined by Gould and Plimpton (1985) was used to standardize the instrument. The instrument was permitted to warm up for at least an hour before operation. The sample drawer was completely withdrawn and the reading was allowed to stabilize. The meter was calibrated to a reading of 100. A sample of fried pellets was placed in the sample cup. The sample drawer was closed and the Agtron reading was recorded. All values reported are the means of two observations.

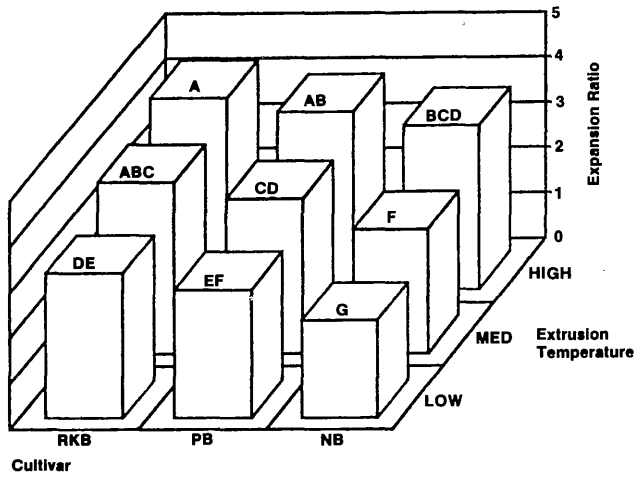
Sensory analysis. Sensory analyses were conducted using a trained panel of 10 Food Technology students at The Ohio State University. The panel consisted of six males and four females between the ages of 19 and 23. A 10-point hedonic rating scale was used to evaluate the flavor of the fried, expanded product.

Statistical analysis. Statistical analysis of the data was conducted to identify significant variations in the observed responses. Analysis of Variance was accomplished using the General Linear Models option of the SAS program (SAS Institute, Raleigh, SC) at The Ohio State University. Mean separation was determined using Tukey's Studentized Range Test with a 95 percent confidence level.

RESULTS AND DISCUSSION

Expansion ratio. The data in Figure 1 illustrate the effects of bean cultivar and extrusion temperature on the expansion ratio. The corn-red kidney bean and corn-pinto bean blends were not significantly different, regardless of extrusion temperature. The corn-navy bean blend had significantly less expansion at lower extrusion temperatures. However, at the high temperature, it was not significantly different from the corn-pinto bean blend. Also, each successively higher extrusion temperature displayed a significant improvement in expansion.

Figure 1. Mean Separation of Expansion Ratio Data.[a]

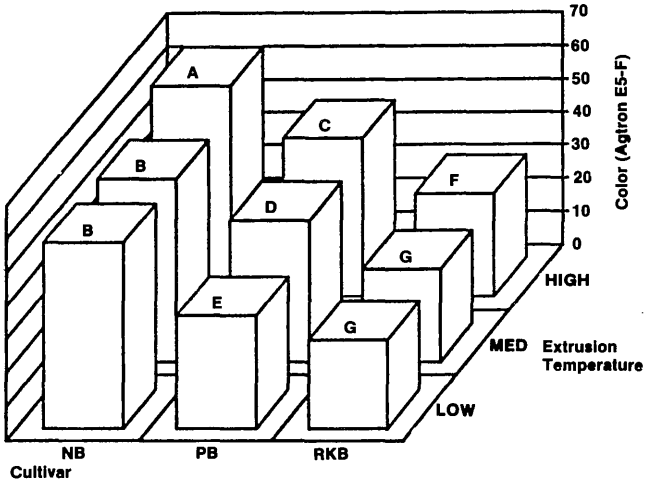


[a]Bars with same letter are not significantly different at 95% confidence level.

There is very little published data on the effect of extrusion temperature on the expansion of half-products. Most information is proprietary and is thus unavailable. However, the relationships found between extrusion temperature and expansion agree with those reported by Aguilera, et al. (1984) for the extrusion of corn-navy bean blends, and Owusu-Ansah et al. (1984) and Mercier and Feillet (1975) for the direct expansion of corn starch.

Agtron E5-F color. The effects of cultivar and extrusion temperature are illustrated in Figure 2. The most obvious difference in colors is between cultivars of bean. The corn-navy bean blend had the brightest color, which was significantly brighter than the corn-pinto bean blend. The corn-red kidney bean blend was obviously

Figure 2. Mean Separation of Agtron E5-F Data[a]



[a]Bars with same letter are not significantly different at 95% confidence level.

much darker than either of the other two bean cultivars. The pH of the corn-bean blends were slightly acidic, ranging from 6.3 for corn-red kidney bean and 6.4 for corn-pinto and corn-navy bean blends. The tannins tend to form highly colored compounds when heated in an acidic solution (Peterson and Thompson, 1978), contributing to the formation of darker pellets upon extrusion.

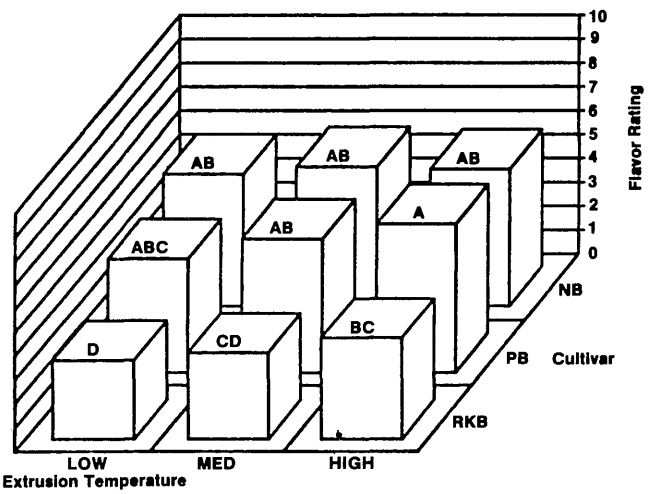
The extrusion temperature also had a significant effect on the color development of the final product. As illustrated in Figure 2, the higher temperature extrusion profiles yielded brighter products. This effect can be explained in terms of expansion of the product upon frying. With higher extrusion temperatures, more gelatinization of the starches resulted in greater expansion. This had the effect of diluting the oxidized tannins throughout a greater area, thus reducing the coloration of the final product.

Flavor preference. The separation of means for flavor preference data is illustrated in Figure 3. It is evident from the data in the graph that there was no significant difference ($\alpha = .05$) between the corn-navy bean and corn-pinto bean blends, regardless of extrusion temperature.

The corn-red kidney bean blend was found to have unacceptable flavor at lower extrusion temperatures. This can be attributed to the presence of condensed tannins that are found in the bean seed coat. These tannins, which also impart a deep red pigment to the material, are also remarkable for their astringent taste. Some researchers do not consider this astringency to be a true taste, but rather a sense of touch. It is caused by the coagulation of proteins in the saliva in the mouth, resulting in a reduction of lubrication (Peterson and Johnson, 1978). This astringency imparts a dry bitterness to the product that the panelists found to be undesirable.

Perhaps the most interesting finding is the significant improvement ($\alpha = .05$) of the corn-red kidney bean blend at higher extrusion temperatures. At the highest extrusion temperature profile, the corn-red kidney bean blend is not significantly different from the corn-navy bean blend at the same extrusion treatment. This indicates that the elevated temperatures during extrusion may break the polyphenolic structure of the tannins down into lower molecular weight molecules that are different in sensory properties, or are subsequently volatilized. Perhaps more rigorous extrusion conditions would produce a more acceptable product in terms of flavor.

Figure 3. Mean Separation of Flavor Preference Data.[a]



[a]Bars with same letter are not significantly different at 95% confidence level.

SUMMARY AND CONCLUSIONS

There are several conclusions that can be drawn from the results in this study. The first is that an acceptable, high-protein snack food can be manufactured from blends of raw corn and bean flours.

Second, the cultivar of bean affects the functional and organoleptic characteristics of the finished snack food. The data indicate that the corn-red kidney bean and corn-pinto bean blends had similar expansion and textural properties, yet the corn-pinto bean blend was found to be superior to the corn red kidney bean blend in all sensory evaluations. Although the corn-navy bean blend exhibited low expansion and a tough texture, it too was rated higher than the corn-red kidney bean blend in all sensory evaluations. The preference data for the finished products indicate that panelists preferred a bland product over more astringently flavored products. These findings reveal that these bland products could be used as carriers for more refined flavors such as cheese flavoring, barbeque flavoring or other popular seasonings. Other considerations are that highly pigmented beans should receive preliminary treatment before being incorporated into a snack food blend. Astringent flavors, as well as antinutritional factors, can be reduced by dehulling.

Third, the extrusion parameters used also interact with the product formulation to change final product characteristics.

The protein fortification of foods is generally not a concern for most people in developed nations. However, there are populations in less fortunate societies who require an additional source of inexpensive, high-quality protein. These fortified foods must be extremely stable during storage, and must be simple to prepare in the home. The snack food pellets produced in this study have a high bulk density before frying, making them very cost-effective in transportation. Their low moisture content and horn-like outer shell provide resistance to microbial degradation and rodent infestation. In the home, they can be easily prepared by popping in hot oil.

These high protein snack food pellets, after frying or popping, can be an effective aid in improving the nutritional status of children in developing nations.

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VISCOSITY AND LYOPHORESIS OF COMMINUTED TOMATO PRODUCTS

Wennie L. Lloyd and Wilbur A. Gould[1]

INTRODUCTION

One of the primary concerns of tomato manufacturers is ensuring maximum utilization of the tomato. One question that frequently arises addresses the consistency (or its corollary—viscosity) of the resultant products. The other problem that is encountered by processors in most comminuted tomato products is the maintenance of cloud and a stable suspension of solids which give the products a good appearance and proper rheological properties. This phenomenon of juice separation into solids and serum has been termed lyophoresis. It occurs upon prolonged storage and affects the aesthetic acceptability and overall product rheology.

These problems are addressed in this study by providing a basic understanding of 1) the change of potential viscosities and lyophoresis of tomato cultivars from one year to another, 2) the viscosity of the cultivars when used in different products, 3) the rate of lyophoresis, and, 4) the effect of temperature on the product lyophoresis.

MATERIALS AND METHODS

The experimental work carried out in this research was conducted during the summer of 1983 and 1984 at The Ohio State University Food Processing Pilot Plant and Analytical Laboratories, Department of Horticulture.

Ten tomato cultivars grown under usual commercial conditions at the Vegetable Crops Branch of the Ohio Agricultural Research and Development Center, Fremont, Ohio, were analyzed in 1983 and 1984. The selection of the cultivars was based on the different viscosities and lyophoresis of their products. The names and codes of these cultivars are listed in Table 1.

Processing of Tomato Juice

The tomatoes were processed into juice within 24 hours after their arrival using the conventional processing operation for canned tomato juice manufacture. They were sorted, washed, graded, chopped and then hot-broken at a temperature greater than 88°C (190°F) for 15 seconds. The latter step inactivated the pectic enzymes inherent to the fruits. The juice was extracted from the crushed heat-treated tomatoes using a Langsenkamp screw type extractor with a screen size of 0.058 cm (0.023 in). Sterilization was accomplished by holding the juice at 121°C (250°F) for 42 seconds. The product was cooled and then filled into 303 fruit enamel cans (each with a 30-grain salt tablet), sealed, coded, held for 3 minutes, then spin-cooled to a temperature of 38-41°C (100-105°F). The canned tomato juice was then analyzed for viscosity and lyophoresis.

[1]Graduate Student and Professor Emeritus

Concentration of Tomato Juice

Preliminary operations for the concentration of tomato juice were the same as those involved in the tomato juice manufacture up to the extraction step. Approximately 200 L of the extracted tomato juice from each cultivar were concentrated using a Hamilton vacuum pan evaporator (Hamilton Kettles, Cincinnati, OH), operated at a temperature of 46°C (140°F) under a 21" vacuum. Samples were concentrated so that a thick viscosity was evident, ie. °Brix readings of 9-26 depending upon the cultivar.

Preparation of 12°Brix Concentrate

The concentrated products were rediluted by adding deionized distilled water to the product, stirring, and completely mixing the solution. Water was added until the refractive index read 1.3508 to 1.3511, corrected to 20°C. These readings convert to 12.0 percent + 0.1 percent natural tomato soluble solids (NTSS).

Juice Viscosity Measurement

The GOSUC viscometer was used for viscosity measurement of canned tomato juice. The instrument was standardized with distilled water so that a flow of 150 ml was completed in 32 seconds at 21.1°C (70°F). The period of time it took for a given volume of sample to travel the tube distance was recorded as the viscosity.

Concentrate Viscosity Measurement

The Bostwick consistometer was used to measure the viscosity of the concentrate. The average distance traveled by the sample in a 30-second time period was recorded as the viscosity. Measurements were conducted at 21.1°C (70°F).

Reconstituted Concentrate Viscosity Measurement

The Hunt's Funnel was used to determine the viscosity of the 12°B reconstituted juice. A stopwatch calibrated in seconds was used to determine the time it took for the sample to travel the distance between the etch marks on the funnel. Viscosity determination was conducted at 21.1°C (70°F) as suggested by the instrument specifications.

Lyophoresis

Lyophoresis or separation of the juice serum and solids was determined by placing a 50 ml sample (preserved with 0.2 percent sodium benzoate) in a 50 ml test tube. The samples were set in an upright position for a period of 35 days at room temperature, 21.1°C (70°F) without any disturbance. Another set of samples were set at 38.0°C (100.4°F). Lyophoresis which occurred was recorded as ml clear serum per 50 ml of juice sample.

Statistical Analyses

Analyses of variance with interaction procedures were utilized to establish significance of the effects of cultivars, year, and cultivar X year on product viscosities and lyophoresis. The same analysis was utilized to determine significance of the effects of temperature, cultivar, and cultivar X temperature on lyophoresis. The Duncan's Multiple Range Test at $P < 0.05$ was used to identify differences (Steel and Torrie, 1980). P is the probability of chance occurrence.

RESULTS

Viscosity and Lyophoresis of Juice and Concentrates

In 1983 and 1984, the chosen cultivars were analyzed and processed into juice and concentrated products. Changes in viscosity measurements were observed from 1983 to 1984 both in juice and concentrates among the cultivars (Table 1). Analyses of variance revealed that such changes in viscosities were affected by the interactions between the cultivar and the processing year and that the interactions were significant ($P < 0.01$). The Duncan's multiple range test at $P < 0.01$ for the viscosity means for juice and concentrates are represented in Figures 1 and 2, respectively.

Cultivar differences are also shown in the significance ($P < 0.05$) of the variations of viscosities of 12°B reconstituted samples from the 1984 processing season. The differences are represented by Figure 3.

Using the data obtained for juice, concentrate and 12°B reconstituted juices, a correlation analysis was conducted. Shown in Table 2 are the mean viscosities and their correlations. Very low correlation was found between juice and concentrate viscosities ($R = 0.438$, $P < 0.053$) while no significant correlation was found between juice viscosity X reconstituted concentrate viscosity, and reconstituted concentrate viscosity X concentrate viscosity.

Table 1. Tomato cultivars and their lyophoresis and viscosity characteristics.

Code Number	Cultivar	Lyophoresis	Juice* Viscosity	Concentrate** Viscosity
C21	Peto 9543	yes	High	High
C1	Ohio 833	yes	High	High
C19	Ohio 8297	no	High	High
C32	Heinz 1784	yes	High	Low
C13	Ohio 8153	no	High	Low
C2	Ohio 832	yes	Low	High
C5	Campbell 4135	yes	Low	High
C16	Ohio 8290	yes	Low	High
C3	Heinz 2653	yes	Low	Low
C11	Ohio 8129	yes	Low	Low

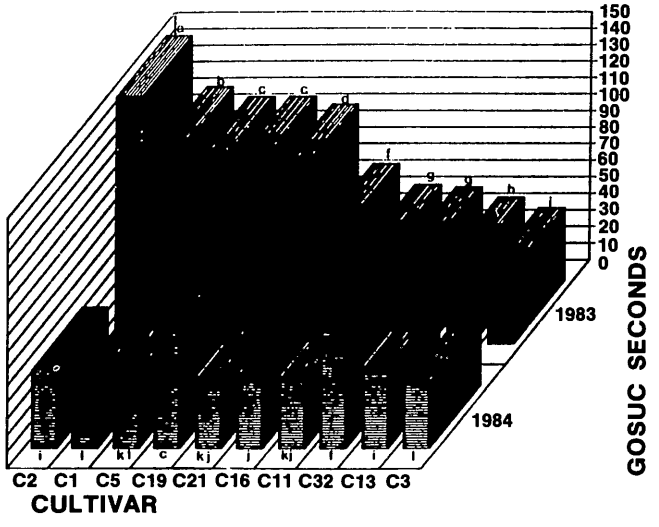
* High Viscosity is greater than 60 GOSUC Seconds
Low Viscosity is equal to or less than 60 GOSUC Seconds

** High Viscosity is less than 7.0 Bostwick cm.
Low Viscosity is equal to or greater than 7.0 Bostwick cm.

Lyophoresis - Cultivar and Year Effect

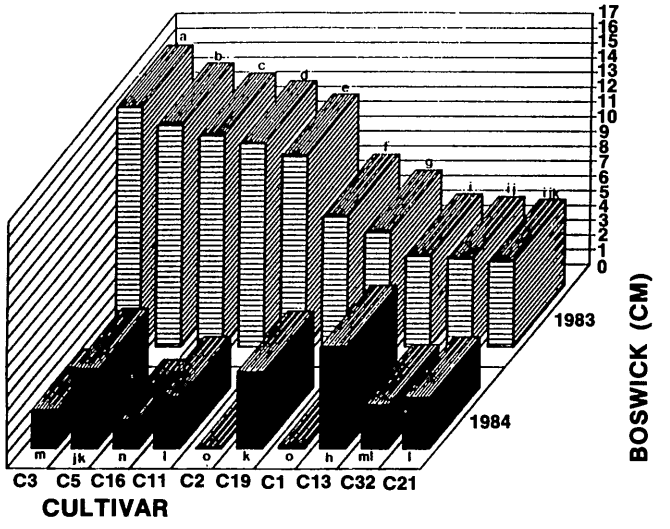
The occurrence of lyophoresis in tomato juice during the two years of study was consistent. The interaction effect of cultivar X year to the degree of lyophoresis was not significant at $P < 0.05$. The main effects, therefore, of cultivar and year are represented in Figures 4 and 5. The

Figure 1. Average juice viscosities of tomato cultivars for 1983 and 1984.



Cultivar X Year interaction effect on viscosity is significant at $P < 0.01$. Means with the same letters are not significantly different at $P < 0.05$.

Figure 2. Average tomato concentrate viscosity for 1983 and 1984.



Cultivar X Year interaction effect on viscosity in significant at $P < 0.01$. Means with the same letters are not significantly different at $P < 0.05$.

various cultivars resulted in significant differences in lyophoresis ($P < 0.05$). The difference in year effect on lyophoresis is significant at $P < 0.02$.

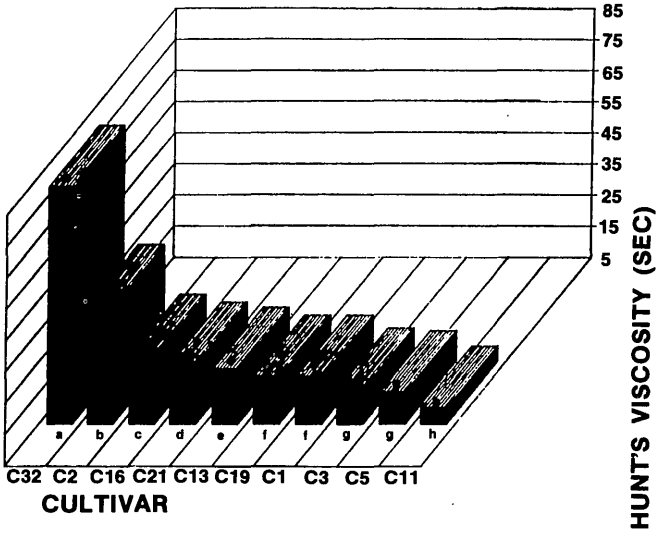
Development of Clear Serum

The development of clear serum in juice samples at 21°C followed the trend shown in Figure 6. Maximum separation was achieved after 28 days for samples that developed high and medium amounts of clear serum (C21, C2, C32, and C3) while for the samples that formed low levels of separation (C5 and Cl) maximum separation was attained after 21 days. The increase after 14 days for the latter samples was minimal.

Temperature Effect on Lyophoresis

The temperature effect on development of separation was determined by evaluating selected samples at 38°C (100°F) and at 21°C (70°F) (Figure 7). No significant effect on the interaction of cultivar X temperature on the lyophoresis was found. Cultivar and temperature differences are shown in Figures 8 and 9.

Figure 3. Average viscosity of 12°B reconstituted concentrate.



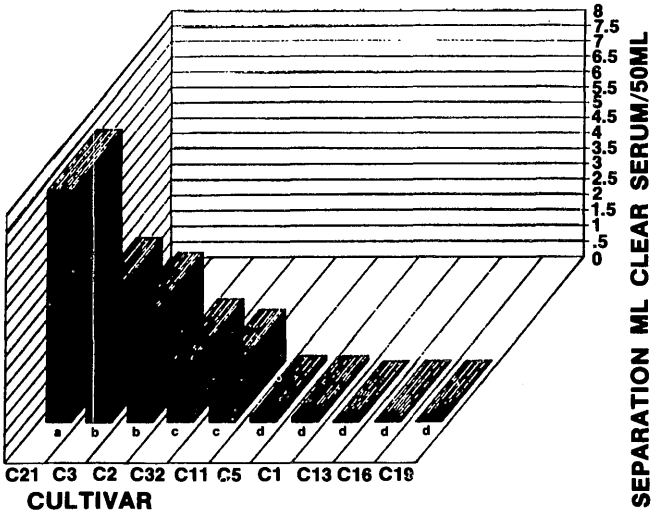
Means with the same letters are not significantly different at $P < 0.05$.

Table 2. Mean viscosities of comminuted tomato products and their correlation coefficients.

Cultivar	Mean Viscosities: Juice (Sec)	Concentrate (cm)	Reconstituted (Sec)
C19	73.46	5.30	20.50
C32	70.52	3.00	80.75
C13	46.11	7.00	22.40
C2	46.53	0.00	42.75
C16	42.66	1.93	26.85
C21	41.38	3.53	24.25
C11	41.27	3.53	10.05
C5	39.13	5.50	15.00
C1	38.96	0.10	20.05
C3	38.18	2.70	15.90

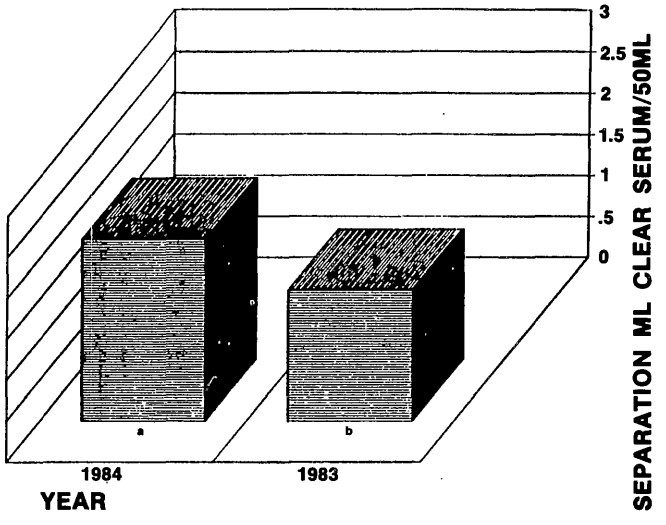
R (Juice.Concentrate) = 0.438
R (Juice.Reconstituted) = 0.364
R (Concentrate .Reconstituted) = −0.212

Figure 4. Effect of cultivar on lyophoresis of tomato juice.



Means with the same letters are not significantly different at $P < 0.05$.

Figure 5. Effect of year on lyophoresis of tomato juice.



Means with the same letters are not significantly different at $P < 0.05$.

DISCUSSION

Some differences between the juice viscosities of the same cultivars were observed during the processing years 1983 and 1984. The same is true for the concentrates, although the differences between the two years can be attributed to the final concentration. For the juice, however, the significant effect on the viscosity of cultivar X year ($P < 0.01$) can be explained by the cultivar factors which differed between 1983 and 1984. These differences could be due to varying climatic conditions, horticultural practices, or processing parameters over the two-year period. Genetic variation within a cultivar should not be a factor in this study. Therefore tomato selection for juice production or any processing use should not be based on the cultivar's past performance alone.

Figure 6. Development of clear serum during a given time interval (@ 21°C).

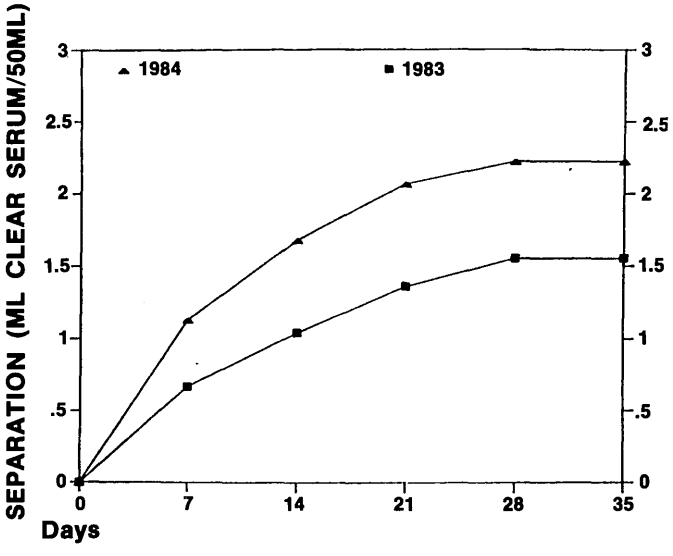
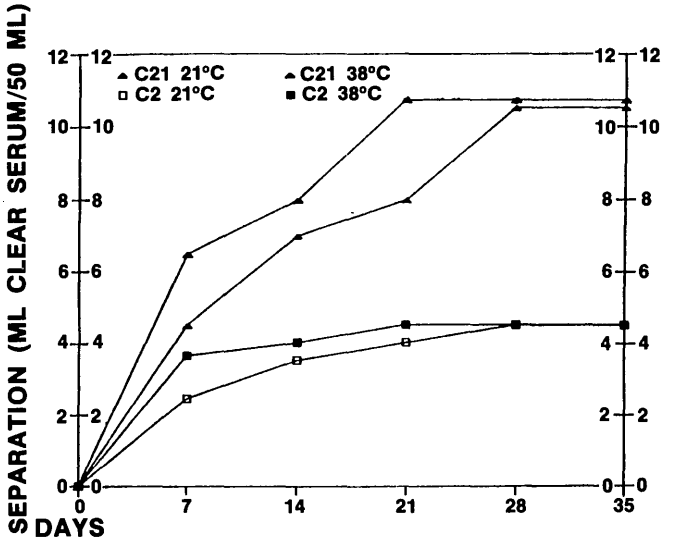
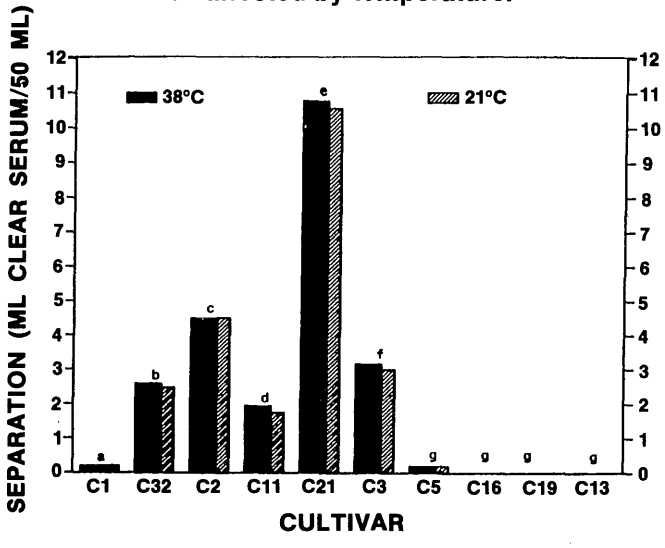


Figure 7. Development of clear serum at 21°C and at 38°C of C21 and C2.



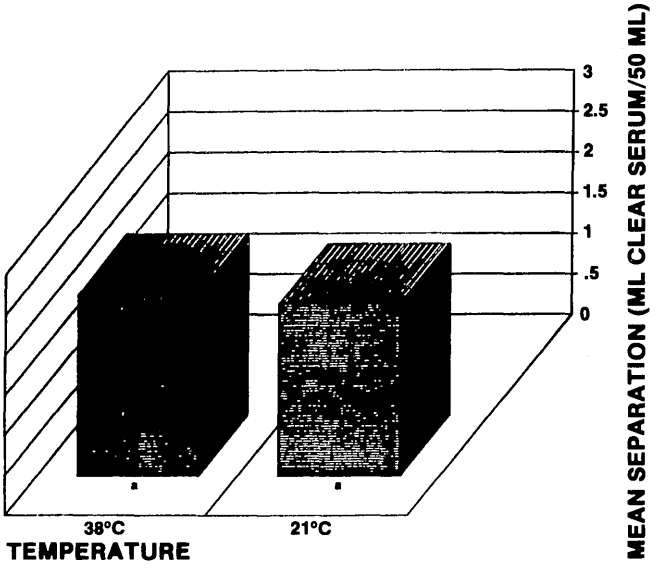
The same significant interaction effect of cultivar X year ($P < 0.01$) to viscosity was found with the concentrates. This means that a cultivar can produce a high viscosity concentrate in one year and a low one in another, and that the amounts of the change of viscosities among the cultivars are not consistent. The concentrates in 1983 are generally lower in mean consistency than in 1984. This could be attributed to the fact that in 1984 the juices were concentrated to higher solids range (°Brix) than in 1983.

Figure 8. Juicy lyophoresis of tomato cultivars as affected by temperature.



Cultivar X Temperature interaction effect on the lyophoresis of cultivar is not significant at $P < 0.05$. The means with the same letters are not significantly different.

Figure 9. Effect of temperature on juice lyophoresis.



Cultivar X Temperature interaction effect on the lyophoresis of cultivar is not significant at $P < 0.05$. The means with the same letters are not significantly different.

A comparison of cultivars based on a reconstituted product viscosity of 12° Brix as suggested in the USDA methods of analyses for tomato product (1971) was conducted. Significant differences ($P < 0.01$) were found in reconstituted viscosity. Cultivar 32 showed a far superior viscosity (80.75 sec). Most of the cultivars fell within the viscosity range of 20-25 seconds as measured with the Hunt's funnel. Knowing that cultivar 32 (°B = 23.6) was concentrated to about the same magnitude as some of the other cultivars (C5, C3, C1, C13, C2, C19, °B = 22.0-26.0), and with its initial Bostwick consistency being comparable with the others (C2, C16, C1), it can be hypothesized that a cultivar's suitability for reconstitution or remanufacture should not be based on the viscosity of the paste, but rather on properties which may be physical, chemical, or structural in nature. Studies in these areas will prove useful for processors who use paste for manufacturing other tomato products.

The results showed that the 12°B product does not accurately reflect the paste consistency and that changes occur during reconstitution which alter do not permit one to predict final product viscosity. One change that possibly occurred during the redilution process is the absorption of dilution water by the shrunken cell walls of the dehydrated concentrate. Shomer et al. (1984) showed that the transparent, soft wall vesicles of the tomato are capable of responding to osmotic stresses by shrinking and swelling upon transfer from hypotonic to hypertonic solutions are vice versa. If such phenomena occur during redilution, the hydrodynamic cell volumes in reconstituted product would be different from those of the concentrate. The rediluted samples would therefore differ in viscosity depending on their degree of dilution.

Juice lyophoresis was not significantly affected by cultivar X year interaction. The change in the separation of one cultivar from the first year to the next did not significantly differ from the change that occurred in another cultivar ($P < 0.05$). The effect of cultivar difference on lyophoresis was highly significant ($P<0.01$). Five cultivars (5, C1, C13, C16, C19, showed excellent stability of the juice cloud while C21, C3, and C2 showed very high to moderate degree of separation. Cultivar 21 which has a mean separation of 7.5 ml / 50 ml juice can be considered a poor sample because of its high tendency to separate.

The data also indicate that lyophoresis of the juice in 1984 was significantly lower than that in 1983. The results were as expected bescause juice viscosities in 1984 were significantly lower than those in 1983. The generalization that juice of lower viscosities has a greater tendency to separate is supported by these findings.

On the average, maximum separation of the juice was achieved after 28 days of storage at room temperature (21°C) although for low separating cultivars, only a minimal increase in serum volume was observed from the 14th to the 35th day. The homogeneous appearance of tomato juice depends on the stable distribution of large cell walls and residues of protoplasmic constituents through the serum column (Shomer et al., 1984). The study showed that the distribution of these insoluble particles changes during storage. The difference in the duration of maximum settling by cultivars warrants the need for further study on factors influencing lyophoresis.

Additional experiments revealed that temperature does not have a significant effect on lyophoresis ($P < 0.05$). The amounts of clear serum formed in the juice column at 38°C were only slightly higher than those formed at 21°C. Settling of the insoluble particles occurred faster at higher temperatures. This could be attributed to decreased serum densities at higher temperatures. Although the reversibility of the lyophoretic mechanism was not studied, conditions under which tomato products are stored may be of concern to the processing industry.

CONCLUSIONS

The important findings of this study are summarized in the following:

1) The viscosities of tomato juice and concentrate made from the same cultivar varied from year to year. These variations were significant.

2) Higher concentrations (°B) and viscosities of tomato juice concentrate did not yield higher viscosities upon reconstitution.

3) Lyophoresis is related to product viscosity. The less viscous the product the greater the amount of clear serum formed.

4) The rate of clear serum formation was slightly higher at a higher temperature. However, the final volume of clear serum formed was not affected by temperature.

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FATTY ACID COMPOSITION OF COCONUT AND PALM OIL

B. A. Rodriquez and A. C. Peng[1]

INTRODUCTION

Fatty acid composition of an oil has been used as an expression of oil quality. Different oils may have different fatty acid composition due to environmental conditions, growing factors, and variety and cultural practices. Fatty acids can also be used to identify unknown mixtures, alterations or adulteration (11), and to check the specifications of supplies and products (3).

Coconut oil is the most important oil in the lauric acid oil group and contains a high proportion of glycerides with short chain fatty acids, particularly lauric acid (2). Fatty acid content varies according to plant age and variety, soil type and fertility, humidity, cultural practices, and stage of fruit maturity (15). This oil contains 84 percent GS_3, 12 percent GS_2U, and 4 percent GSU_2 (16). The trading rules commonly used in the United States for crude coconut oil requires a free fatty acid content (calculated as oleic acid) under 3 percent (12).

The quality of palm oil is quoted on the basis of its free fatty acid content, normally between 5-15 percent (14). Crude palm oil has a deep orange red color and contains approximately equal amounts of saturated and unsaturated fatty acids with palmitic and oleic acids as the main components (6).

The purpose of this study was to determine and compare the fatty acid composition of coconut oil and palm oil from different sources.

MATERIALS AND METHODS

Three brands of coconut oil were obtained from Santo Domingo, The Dominican Republic: Aceite Supremo by the Sociedad Industrial Dominicana, Aceite Dorado by the Industrias Lavador C. por A., and Oro Viejo by the Industrias de Aceites Vegetales C. por A.

Three palm oil samples were purchased in Columbus, Ohio: African Maid of Liberia, Africa, imported by La Prefereida, Inc., Bronx, New York; Sands imported from West Africa by Sands African Import, Ltd., New York; and Goya (source unknown) distributed by Goya Foods, Inc., Secaucus, New Jersey.

Methyl esters of fatty acids were prepared by boron trifluoride-methanol (8). They were analyzed by a Packard model 409 Becker gas chromatograph (Packard Instrument, Downers Grove, IL) equipped with a flame ionization detector and a Bristol's dynamaster recorder with a disc integrator. A stainless steel column (244 cm x 0.3 cm) was packed with 15 percent by weight of diethylene glycol succinate (DEGS) on Chromosorb W, AW, 80/100 mesh, and 1 percent by weight of phosphoric acid (9). The operating conditions were: 190°C, column temperature; 220°C, detector temperature, and 240°C, injection port. The carrier gas was nitrogen at a flow rate of 21 ml/min. Identification of the fatty acid composition was made by comparing the retention time of reference compounds under identical conditions, and by plotting the retention time vs. carbon number on a semilog paper to determine those fatty acids not present in the reference compounds. The quantitative distribution of each peak area corresponding to the respective fatty acid was measured by the integrator counts. The ratio of the area counts of each peak to the sum of the area counts of total fatty acid peaks gave the percent of fatty acid composition.

Free fatty acids were determined by AOCS method Ca 5a-40 (1). This was a potentiometric titration to the phenolphthalein end point. The free fatty acid was calculated as percent of oleic acid.

RESULTS AND DISCUSSION

The distribution of main fatty acids of coconut oil, as shown in Table 1, was within the range established by the Codex Alimentarius Commission (CAC) of FAO/WHO (4), except that lauric acid (12:0) was lower and myristic acid (14:0) was higher than the CAC standard. This discrepancy could be attributed to the difference in sources, variety, maturity, or environmental factors. Most coconut oils reported in the literature contained 90-91 percent saturated and 9-10 percent unsaturated fatty acids (13). However, this study indicated that 85.8 percent of

Table 1. Fatty acid composition of coconut oil (%).

Fatty Acid[1]	Composition	CAC Standard[2]
8:0	4.3 ± 2.3	3.4 – 15.0
10:0	5.6 ± 1.5	3.2 – 15.0
11:0	0.3 ± 0.1	–
12:0	34.9 ± 3.2	41.0 – 56.0
13:0	0.4 ± 0.1	–
14:0	26.8 ± 2.3	13.0 – 23.0
16:0	11.1 ± 1.9	4.2 – 12.0
18:0	2.4 ± 0.8	1.0 – 4.7
18:1	10.6 ± 2.1	3.4 – 12.0
18:2	3.7 ± 1.1	0.9 – 3.7
U/S	0.2	

1 — Carbon number: number of double bond
2 — Codex Alimentarious Commission Standard (4).

[1]Graduate Student and Professor

the fatty acids was saturated while 14.2 percent was unsaturated. The major fatty acids were lauric (12:0), 34.9 percent; myristic (14:0), 26.8 percent; palmitic (16:0), 11.1 percent; and oleic (18:1), 10.6 percent. The sample also contained 0.7 percent odd carbon fatty acids, 0.3 percent undecanoic (11:0), and 0.4 percent tridecanoic (13:0), which is considered normal since vegetable oils may contain as high as 2 percent odd carbon acids (5). The unsaturation/saturation ratio was 0.2 (Table 1).

The average fatty acid composition of three palm oils is presented in Table 2. In contrast to the low unsaturation/saturation ratio for coconut oil, 0.2, palm oil was much higher at 1.5. Theoretically, the palm oil should contain approximately 50 percent saturated and 50 percent unsaturated fatty acids (3,6,14). However, this study indicated only 39.9 percent saturated which is considered relatively low (6,7,10). Palmitic (16:0), 32.7 percent; oleic (18:1), 45.2 percent; and linoleic (18:2), 14.7 percent were the main fatty acids found in palm oil which were in agreement with the CAC standard (4). Similar to the coconut oil, a small amount of odd carbon acids was present in the palm oil, 0.1 percent pentadecanoic acid (15:0) and 0.2 percent heptadecanoic acid (17:0). The primary difference in fatty acid composition between the two oils was the high content of short chain fatty acids in coconut oil, 72.3 percent of 8:0 to 14:0 (Table 1). Palm oil was predominated by long chain fatty acids, 97.8 percent of 15:0 to 20:0 (Table 2).

In Table 3, each brand of coconut oil differed in fatty acid composition. However, the mean value of each fatty acid in each coconut oil was very close to the CAC standard (Table 1). The mean values of all palm oil fatty acids (Table 4) were also within the range of the CAC standard (4). The Sands brand was higher in palmitic (16:0) and oleic (18:1) acids, whereas Goya was high in linoleic (18:2) acid, an essential fatty acid. The major fatty acids, 10:0, 12:0, 14:0, 16:0 and 18:1 in coconut oil, and 16:0, 18:0, 18:1 and 18:2 in palm oil were considered important in determining their behavior, characteristics, and properties.

Coconut oil had lower free fatty acids (FFA) than the palm oil (Table 5). The difference in FFA may be due to

Table 2. Fatty acid composition of palm oil (%)

Fatty acid[1]	Composition	CAC Standard[2]
10:0	0.1 ± 0.1	–
12:0	0.4 ± 0.1	1.2
14:0	1.8 ± 0.4	0.5 – 5.9
15:0	0.1	–
16:0	32.7 ± 2.3	32.0 – 59.0
17:0	0.2 ± 0.1	–
18:0	4.5 ± 0.9	1.5 – 8.0
18:1	45.2 ± 2.3	27.0 – 52.0
18:2	14.7 ± 3.1	5.0 – 14.0
18:3	0.2 ± 0.1	1.5
20:0	0.2 ± 0.1	1.0
U/S	1.5	

1 — Carbon number: number of double bond.
2 — Codex Alimentarius Commission Standard (4).

Table 3. Fatty acid composition of individual coconut oil (%).

	Composition[2]			
Fatty Acid[1]	CSUP	CDOR	CORO	RANGE
8:0	7.1	2.1	3.7	1.9 - 7.2
10:0	4.5	6.3	6.2	3.8 - 8.0
11:0	0.2	0.3	0.2	0.1 - 0.3
12:0	38.4	31.5	34.9	31.0 - 39.3
13:0	–	0.4	0.4	0.3 - 0.5
14:0	25.4	28.7	26.3	25.1 - 31.3
16:0	8.6	12.1	12.6	8.0 - 12.8
18:0	2.8	2.9	1.6	1.6 - 3.3
18:1	8.0	12.0	11.9	7.8 - 13.5
18:2	4.8	3.9	2.5	2.3 - 5.2

1—Carbon number:number of double bond.
2—CSUP = Supremo, CDOR = Dorado, CORO = Oro Viejo

Table 4. Fatty acid composition of individual palm oil (%).

	Composition[2]			
Fatty Acid[1]	PSAN	PGOY	PAFR	RANGE
10:0	0.1	–	0.1	0.1
12:0	0.4	0.3	0.5	0.2 - 0.5
14:0	1.8	1.8	2.1	1.5 - 2.1
15:0	0.1	0.1	0.1	0.1
16:0	33.4	32.3	32.4	30.1 - 35.7
17:0	0.2	0.1	0.2	0.1 - 0.3
18:0	4.6	3.7	5.4	3.3 - 5.5
18:1	46.2	44.6	45.0	43.1 - 49.2
18:2	13.1	16.9	14.2	11.6 - 19.9
18:3	0.2	0.2	0.1	0.1 - 0.2
20:0	0.2	0.2	0.1	0.1 - 0.2

1 — Carbon number: number of double bond.
2 — PSAN = Sands,PGOY, = Goya, PAFR = African Maid.

Table 5. Average free fatty acid content of individual oil.

Oil Sample	% FFA (as oleic)
Coconut oil	
Supremo	0.03
Dorado	0.05
Oro Viejo	0.10
Palm oil	
Sands	9.06
Goya	4.75
African Maid	6.15

the quality and storage conditions of raw material, source, variety, moisture, and processing conditions. More importantly, coconut oil has large concentrations of saturated fatty acids which may contribute to better stability and keeping quality than palm oil, which is high in unsaturated acids. In addition, palm fruit is susceptible to enzymatic hydrolysis after harvesting if not properly handled. This may be another cause for its higher free fatty acid content (12).

In summary, oils from different sources have different fatty acid compositions. Coconut oil was high in short chain fatty acids and palm oil was high in long chain fatty acids. Coconut oil had much less free fatty acid than palm oil.

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CHEMICAL COMPOSITION AND SENSORY PROPERTIES OF COOKIES MADE FROM SOYBEAN FLOURS

S. H. Chang and A. C. Peng[1]

INTRODUCTION

Cookies, using wheat flours as the major basic ingredient, are always considered a good carbohydrate source. Generally a cookie contains approximately 4.3 percent protein, 20 percent fat and 71.4 percent carbohydrates (2). Soybean protein products have served as a protein source for the oriental people for centuries because they are an inexpensive source of high-quality protein and are relatively rich in lysine (10). The whole soybean contains about 20 percent fat and 40 percent protein (4), and its amino acid composition is comparable to the FAO recommended pattern (3,5).

Since no published literature reports the complete substitution of soybean flours for wheat flours, this study was designed to find the possibility and feasibility of using soybean flour as the major basic ingredient in cookie making.

MATERIALS AND METHODS

Materials included defatted and lecithinated soy flour were provided by Central Soya Co., Ft. Wayne, IN. Other ingredients were purchased from local supermarkets.

Methods of the experiment include:

1. Analysis of soy flours - all samples were analyzed in triplicate according to AOAC methods (1).

The moisture content was determined by weight difference before and after drying the samples in a recirculating oven at 100 ± 1°C for 18 hours (14.076).

The ash content was measured by igniting the samples in an ashing furnace at 525°C for 18 hours (14.006).

Protein content was determined by microKjeldahl method and calculated as follows: (14.063)

$$\% \text{ Protein} = \frac{(\text{mL HCl of sample} - \text{mL blank}) \times N \times 1.4008 \times 6.25}{\text{Weight of sample}}$$

Fat content was analyzed by using ether extraction and calculated as follows: (14.081)

$$\% \text{ Fat (dry wt)} = \frac{\text{Weight of fat}}{\text{Weight of dried sample}} \times 100$$

2. Formulation

To totally replace wheat flour by soy flour for the study of the acceptability, a prototype formula was developed, tested and modified as follows:

Ingredient	Weight (g)	%
Soy flour	150	100.00
Sugar	195	130.00
Margarine	113	75.00
Peanut butter	113	75.00
Baking powder	11	7.30
Egg	48	32.00
Vanilla	7	4.67
Salt	6	4.00

3. Preparation of cookies

All ingredients were weighed into a mixing bowl, then blended by hand for approximately one hour. The batter was allowed to stand for 30 minutes before molding. The molded cookie dough was baked at 177°C for 9 minutes for defatted soy flour cookies and 8 minutes for lecithinated soy flour cookies. Twenty cookies were packed into a commercial air-tight sandwich bag and stored at room temperature (21°C). Samples were removed every week for 5 weeks for analysis.

4. Analysis of cookies

Two cookies were randomly selected and crushed for each analysis. The content of proteins, moisture, ash and fat was determined by AOAC methods. Carbohydrates were calculated by subtracting crude protein, crude fat, ash and moisture from 100, which gave the carbohydrates percentages.

5. Sensory evaluation

Two different groups of judges, American and non-American, were invited to participate in the taste panel of soy cookies each week. Flavor, color, texture and overall acceptability were evaluated.

6. Statistical analysis

All data were analyzed by SAS System: Analysis of Variance for the chemical analysis and sensory evaluation, and correlation coefficient between storage time and chemical components of two types of cookies.

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RESULTS AND DISCUSSION

Incorporating soy flour into wheat flour to make high protein bakery products has been reported (6,7,8,9). However, the complete replacement of wheat flour by soy flour to make cookies was not studied elsewhere.

The prototype formulation lends itself well to preparation in the average home kitchen. The mixing of all ingredients was difficult since no water was added, and the protein content was very high.

The chemical composition of soy flours is presented in Table 1. Defatted flour was higher protein content whereas lecithinated flour has much higher fat content. This is due to the addition of phospholipid back to the defatted flour.

The chemical composition of cookies (Table 2) did not appear to significantly change during storage. However, when their correlation coefficients were calcualted (Table 3,4), differences appear between storage time, type of cookies, and chemical components. The larger the value of their coefficients, the stronger the relationship.

The fat level in soy flour cookies was about 5 to 17 percent higher than wheat flour cookies. For the defatted soy flour cookies, the fat content ranged from 18.6 to 32.4 percent. This value was 29 to 37 percent for lecithinated soy flour cookies after 5 weeks storage.

High protein levels were obtained from both types of cookies; the protein content remained constant after storage.

The moisture increased slightly. This was probably due to the defect of the ZIPLOC sandwich bag packaging material.

Carbohydrate levels of both cookies were lower than that of wheat flour cookies (about 71 percent).

For the lecithinated soy cookies (Table 3), there was a strong negative relationship between carbohydrates and fat content. Carbohydrate content increased as fat decreased and vice versa. Moisture increased with storage time.

For the defatted cookies (Table 4), again, there was a strong negative relationship between carbohydrates and fat content. Moisture content was positively related to time and negatively related to fat content. Ash content was negatively related to storage time and moisture content, and positively related to fat content.

Table 1. Chemical composition of soy flour (%)

	Moisture	Fat	Protein	Ash
Lecithinated	2.68	15.40	42.91	6.05
Defatted	2.01	3.11	51.10	6.55

Table 2. Mean value of chemical composition of soy cookie.

TIME (week)	FAT (%)		MOISTURE (%)		PROTEIN (%)		ASH (%)		CHO (%)	
	D	L	D	L	D	L	D	L	D	L
0	26.6	31.2	2.9	2.3	18.6	15.2	3.3	3.1	48.6	48.3
1	28.5	30.3	2.8	2.3	18.1	15.1	3.6	3.1	46.9	49.2
2	32.4	37.1	2.7	2.1	17.7	15.7	3.6	3.1	43.6	42.0
3	18.6	31.1	3.2	3.3	18.1	15.6	3.3	2.9	56.9	47.1
4	23.6	30.7	3.8	4.9	18.1	15.6	3.2	3.1	51.3	45.7
5	25.9	28.9	3.5	3.0	18.1	15.6	3.2	3.0	49.3	49.5

D = DEFATTED COOKIES
L = LECITHINATED COOKIES

Table 3. Correlation coefficients of factors of lecithinated soy cookies.

	TIME	FAT	MOISTURE	PROTEIN	ASH	CHO
TIME	1.00	−0.30	0.65	0.45	−0.34	0.01
FAT	−0.30	1.00	−0.36	0.23	0.14	−0.91
MOISTURE	0.65	−0.36	1.00	0.22	−0.22	−0.03
PROTEIN	0.45	0.23	0.22	1.00	−0.21	−0.46
ASH	−0.34	0.14	−0.22	−0.21	1.00	−0.05
CHO	0.01	−0.91	−0.03	−0.46	−0.05	1.00

Table 4. Correlation coefficients of factors of defatted soy cookies

	TIME	FAT	MOISTURE	PROTEIN	ASH	CHO
TIME	1.00	0.35	0.61	−0.27	−0.54	0.34
FAT	−0.35	1.00	−0.52	−0.19	0.58	−0.99
MOISTURE	0.61	−0.52	1.00	−0.01	−0.65	0.45
PROTEIN	—0.27	—0.19	—0.01	1.00	—0.32	0.14
ASH	−0.54	0.58	−0.65	−0.32	1.00	−0.55
CHO	0.34	−0.99	0.45	0.14	−0.55	1.00

In the sensory evaluation, nationality of judges was reflected by the analysis of variance. In the flavor evaluation, American judges consistently preferred lecithinated soy cookies and non-American judges did not show any distinctions between soy flours. Color of defatted soy cookies was more attractive for both groups of judges. With respect to texture, non-American judges liked defatted soy cookies more than lecithinated soy cookies, but American judges preferred lecithinated soy cookies. However, the difference between two types of cookies was not significant, and both were highly acceptable by all judges. Time of storage demonstrated a highly significant influence on the overall acceptability.

In conclusion, the production of cookies using soy flours is not only feasible, but also desirable because of its high nutritional value, low cost (about 10 to 20 cents per pound of soy flour), consumer acceptability, and chemical stability.

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REDUCING SUGARS AND SAUERKRAUT FERMENTATION

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INTRODUCTION

Fermentation has been used for centuries as a process for preserving foods or altering organoleptic properties. Fermented foods provide variation in present diets and play a major role in the total diet. The sauerkraut industry is experiencing product contamination or failing to reach the required level of total acidity. The problems could be associated with insufficient sugars in the raw material or possibly the presence of residual sugars after fermentation. Therefore, an understanding of the levels of reducing sugars from cabbage and its effect on fermentation is necessary for a high quality sauerkraut. This information may help refine the sauerkraut fermentation process and provide the justification and opportunity for feasible selection of specific cultivars which produce a more favorable quality product.

MATERIALS AND METHODS

Raw materials:

Cabbage used in this investigation was grown at the Ohio Agricultural Research and Development Center Vegetable Branch near Fremont, Ohio. Cultivars were Gourmet, King Cole, Titanic-90, Roundup, Condor, Superboy, and Rodolfo. Samples were stored at 2°C until removed from fermentation.

Sample preparation:

The cabbage head was trimmed to remove defects and outer leaves. Each cabbage head was sampled by using two longitudinal cuts to remove approximately one quarter of the head. This wedge was cored and cut into slaw with a slaw cutter.

Reducing sugar determination:

Duplicate 100 g samples were chosen at random from the bulk slaw. Two hundred mL of distilled water were added to the sample and the mixture was blended in a Waring Blendor for one minute at low speed, and one minute at high speed. This slurry was aliquoted to three tubes and centrifuged in a Sorvall Superspeed RC 2B centrifuge at 0°C and 12,000 RPM for 10 minutes. One mL of supernatant was removed from each tube and diluted according to the Nelson and Somogyi procedure (5). Two mL were withdrawn from each diluted sample, and the reducing sugar was measured by the Yellow Spring Instrument, model 27 industrial analyzer.

Fermentation process:

The quartered cabbage was shredded with a slaw cutter. The slaw was placed into large containers and 2.25 percent salt (w/w) was distributed throughout the slaw. The mixtures were packed in individual fermentation buckets and a septum was placed near the bottom for juice withdrawal. The systems were sealed by covering with a double layer of plastic wrap and labeled. A weight was added to the top surface to keep the slaw compact and to help provide tighter seals. Rubber bands were stretched around the buckets to secure the plastic wrap. All materials used in preparation for the fermenting systems were thoroughly cleaned with detergent and rinsed with water several times prior to use.

Fermentation analysis:

Five mL replicates of kraut juice were removed from each fermenting system through the septum with a syringe and diluted with 45 mL of distilled water. The total volume was centrifuged for 10 minutes as previously described. Two mL of this supernatant was taken for reducing sugar determination (5).

The pH was measured with a Beckman Zeromatic SS-33 pH meter. The total acidity was determined by potentiometric titration and calculated by the following equation as percent lactic acid (3).

$$\% \text{ Acid} = \frac{V \times N \times \text{Meq. Wt}}{Y}$$

Where: V = Volume in mL of NaOH titrated

N = Normality of NaOH (0.1 N)

Meq. Wt. = Milliequivalent weight of acid (0.090)

Y = Volume in mL of sample

Analyses were conducted at a five-day intervals during the thirty-day fermentation experiments.

RESULTS AND DISCUSSION

Fermentation progressed with few problems. Surface contamination was minimal and temperatures were generally maintained at 20°C.

The effect of cultivars on the reducing sugars and total acidity is shown in Table 1. Data indicate that the reducing sugar levels from all cultivars after fermentation increased from 49.7 to 64.0 percent from day 0 to day 5 and then decreased to day 30. The lactic acid production increased throughout the fermentation. Therefore, the sugar-acid ratios were consistently high during the early stages and decreased near the final stages of fermentation. This may be due to the slower rate of acid production during this final stage. The largest change in sugar-acid ratio was found with cultivar Rodolfo and the least with

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Table 1. Effect of reducing sugars among cabbage cultivars on pH and total acidity during fermentation

Cultivar	Days Fermentation	pH	Reducing Sugar*	Total Acidity**	Ratio (sugar/acid)
King Cole	0	6.30	144.5	0.08	1806.25
	5	3.65	287.5	0.81	354.94
	10	3.50	110.7	1.26	87.86
	15	3.45	40.3	1.42	28.38
	20	3.45	26.1	1.44	18.13
	25	3.40	10.1	1.46	6.92
	30	3.40	4.2	1.49	2.82
	r^2***	.4439	.6406	.7098	
Titanic-90	0	6.10	151.2	0.07	2160.00
	5	3.70	382.2	0.94	406.60
	10	3.70	232.1	1.46	158.97
	15	3.60	41.4	1.57	26.37
	20	3.60	18.2	1.60	11.38
	25	3.50	10.8	1.60	6.75
	30	3.55	4.3	1.62	2.65
	r^2	.4431	.5618	.6615	
Roundup	0	6.10	142.9	0.07	2041.43
	5	3.90	396.8	0.97	409.07
	10	3.80	214.3	1.49	143.83
	15	3.60	48.6	1.60	30.38
	20	3.50	23.5	1.66	14.16
	25	3.40	10.4	1.67	6.23
	30	3.40	5.4	1.71	3.16
	r^2	.5658	.5385	.6894	
Condor	0	6.42	136.2	0.05	2724.00
	5	3.90	295.6	0.83	356.14
	10	3.50	125.3	1.22	102.70
	15	3.50	41.7	1.44	28.96
	20	3.50	21.7	1.46	14.86
	25	3.50	9.1	1.48	6.15
	30	3.45	3.8	1.51	2.52
	r^2	.4700	.6182	.7210	
Superboy	0	6.10	136.2	0.07	1945.71
	5	3.90	346.2	0.86	402.56
	10	3.85	214.3	1.40	153.07
	15	3.80	45.2	1.49	30.34
	20	3.70	20.0	1.53	13.07
	25	3.65	14.0	1.53	9.15
	30	3.60	3.0	1.55	1.94
	r^2	.4939	.5637	.6718	

* ug/mL of reducing sugar from 5 mL sample of brine from fermenting system.

** % lactic acid from 5 mL sample of brine from fermenting system.

*** Coefficient of linear determination.

Table 1. Effect of reducing sugars among cabbage cultivars on pH and total acidity during fermentation (continued).

Gourmet	0	6.15	144.5	0.09	1605.56
	5	3.95	367.7	0.09	4085.56
	10	3.90	271.0	1.44	188.19
	15	3.60	45.2	1.55	29.16
	20	3.55	20.9	1.58	13.23
	25	3.60	10.1	1.60	6.31
	30	3.75	3.2	1.60	2.00
	r^2	.4689	.5479	.6753	
Rodolfo	0	6.30	139.6	0.05	2792.00
	5	4.05	352.8	0.88	400.91
	10	4.00	209.5	1.35	155.19
	15	3.80	41.7	1.49	27.99
	20	3.70	17.4	1.51	11.52
	25	3.60	9.8	1.51	6.49
	30	3.65	4.8	1.53	3.14
	r^2	.5403	.5645	.6695	

cultivar Gourmet. As fermentation progressed the changes in reducing sugar and total acidity were significant for all cultivars.

The greatest change in pH during fermentation was found from cultivar Condor which decreased from 6.42 on day 0 to 3.45 on day 30. As expected, pH decreased as fermentation proceeded.

The variation between cultivars significantly affected the reducing sugar levels (136.2 to 151.2 ug/mL) and total acidity (0.05 to 0.09 percent).

The initial reducing sugar of all cultivars from fresh cabbage ranged from 199.54 to 252.97 ug/mL (Table 2). Table final total acidity varied from 1.49 to 1.71 percent. The initial reducing sugar and final total acidity demonstrated a linear relationship.

Table 2. Effect of initial reducing sugar among cabbage cultivars on final total acidity after 30 days of fermentation.

Cultivar	Initial Reducing Sugar*	Final Total Acidity**
King Cole	199.54	1.49
Titanic-90	250.74	1.62
Roundup	252.97	1.71
Condor	208.44	1.51
Superboy	224.03	1.55
Gourmet	250.74	1.60
Rodolfo	220.69	1.53
$r^2 = .7938$		

* ug/mL of reducing sugar from 100 g sample of fresh cabbage.

** % lactic acid from 5 mL sample of brine of a fermenting system.

Cultivar King Cole failed at the end of fermentation to reach the 1.5 percent total acidity required by the Code of Federal Regulations for the commercial production of sauerkraut. This cultivar at the time of harvest did not contain a sufficient amount of sugar in the tissue to produce the required level of acid at the end of fermentation.

Cabbage cultivar appeared to influence the initial reducing sugar levels found in the cabbage tissues. Cultivar variations in reducing sugars were especially evident when comparing the high levels of cultivars Titanic-90, Roundup, Gourmet with the lower levels of King Cole or Condor. These variations agreed with studies by Frazier (2), Tanner (6), Niewohof (4) and Fellers et al. (1).

Analysis of these data demonstrated a significant positive correlation between the initial levels of reducing sugars and the final total acidity after 30 days fermentation (Table 3). The prediction equation is $y = 0.864 + 0.00309$ (INS), where INS equals the initial reducing sugar level in a cultivar and y is the predicted final total acidity.

The reducing sugar levels of 200 ug/mL lead us to believe that an optimum maturity could be defined when a cultivar reaches 200 ug/mL or more of its reducing sugars during its growing period.

The data in this study demonstrated that levels of initial reducing sugars present in the tissues of fresh cabbage may be a possible indicator for predicting the final total acidity at the end of fermentation. When a cabbage cultivar contained higher levels of initial reducing sugar at harvest, the sauerkraut produced from this cabbage also contained higher levels of lactic acid. In this study, when a cabbage cultivar reached its optimum maturity (200 ug/mL or more of initial reducing sugar), the finished sauerkraut would attain the required 1.5 percent acid level.

Table 3. Analysis of variance for regression*.

Days Fermentation	df	MS	F	P(F)
30	1	.168662	153.971	.0000

* Since analysis of variance for regression is significant, there is a significant correlation between initial reducing sugar and total final acidity.

Equation for predicting total final acidity from initial reducing sugar level at 30 days fermentation.

$y = 0.864 + 0.00309$ (I.N.S.)
where y = total final acidity
I.N.S. = initial reducing sugar

In conclusion, the levels of reducing sugar in cabbage tissues of different cultivars were significantly different. The levels of reducing sugars in the brine of the fermenting cabbage decreased as the levels of total acidity in the brine increased during the fermentation of all cabbage cultivars. The pH of the fermenting cabbage brine decreased as the total acidity increased during fermentation. There was a positive correlation between the initial reducing sugar level and the total final acidity produced by fermentation, therefore, the initial reducing sugar levels in the cabbage could be used to predict the final total acidity of the finished product, sauerkraut.

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SUPPLEMENTING SORGHUM FLOUR FOR WHEAT FLOUR IN BREAD

M. P. Gonzalez and A. C. Peng[1]

Sorghum and millet are major cereal crops that are generally grown under semi-arid conditions or as short-term cash crops, when disaster has ruined other crops. Sorghum ranks fifth as a major cereal crop in world production behind rice, wheat, corn and barley. Most sorghum produced in the United States is used for animal feed, however, in other parts of the world, sorghum is consumed by humans.

The chemical composition of sorghum grain is similar to that of other grains. However, the composition is affected and varied by environment, variety, and cultural practices.

This report is an investigation of the chemical composition of a commercial sorghum flour, and the possibility of supplementing sorghum flour for wheat flour in bread.

In the formulation of a baked product, a Dominican bread, "pan de agua" (water bread), a typical hearth bread consumed daily by the Dominican people, was used as a model. The formula is listed below with the modification of incorporating 0, 10, 20, 30 and 40 percent sorghum flour with the dough conditioner, sodium stearoyl lactylate (SSL).

Ingredient	%
Wheat flour	100.00
Water	16.50
Sugar	1.37
Yeast	0.70
SSL	0.50
Salt	0.35

The flavor, crumb color, texture and overall acceptability of the wheat/sorghum bread were examined by a 30-member untrained taste panel.

The chemical composition of sorghum flour, wheat flour and estimation of pan de agua bread (0 to 40 percent sorghum flour added) is presented in Table 1.

Sorghum flour was higher in fiber, fat and carbohydrates, lower in protein, and slightly lower in ash content than wheat flour. The range of estimated composition of the Dominican bread shows that every component was comparable to the wheat flour, especially protein content. Fiber and fat were higher than the wheat flour, the slightly higher fat content made the sorghum/wheat bread more palatable.

The mineral content of sorghum flour and pan de agua bread was evaluated against wheat flour (Table 2). It is apparent that potassium, magnesium, iron, aluminum and boron were higher than the wheat flour. Phosphorus, calcium, manganese, copper, zinc and sodium were lower. The low sodium and high fiber content may be beneficial to the human health. On February 4, 1980, officials from USDA, HSS and the White House released seven dietary recommendations that represent a nutritional guidelines, three of the seven guidelines are (1) avoid too much fat, saturated fat and cholesterol; (2) eat foods with adequate starch and fiber; and (3) avoid too much sodium. The sorghum/wheat bread seems to be ideal for those requirements, low fat, high fiber and carbohydrates, and low sodium.

Table 1. Chemical composition of sorghum flour, wheat flour and pan de agua bread.

Composition	Sorghum flour (%)[a]	Wheat flour (%)[b]	Pan de agua bread (estimated, %)[c]
Moisture	8.54	12.00	10.61 - 12.00
Ash	0.57	0.65	0.62 - 0.65
Fiber	1.92	0.50	0.50 - 1.07
Fat	1.97	1.30	1.30 - 1.57
Protein	9.54	12.00	11.02 - 12.00
Carbohydrates	77.46	74.10	74.10 - 75.44

a — "As is" basis.
b — Watt, B.K. and Merrill, A.L. 1963. "Composition of Foods. " USDA Agriculture Handbook No.8, Washington, D.C.
c — Based on the range of 0 to 40% sorghum flour added.

Table 2. Mineral content of sorghum flour, wheat flour and pan de agua bread (ug/g)

Element	Sorghum flour[a]	Wheat flour[b]	Pan de agua bread (estimated)[c]
Phosphorus	934.5	1,300.0	1,153.8 - 1,300.0
Potassium	1,656.0	1,500.0	1,500.0 - 1,562.4
Calcium	85.2	202.0	155.3 - 202.0
Magnesium	853.7	300.0	300.0 - 413.5
Manganese	5.1	8.0	6.8 - 8.0
Iron	79.0	14.0	14.0 - 40.0
Boron	5.1	2.0	2.0 - 3.2
Copper	1.2	2.0	1.7 - 2.0
Zinc	6.6	19.0	14.0 - 19.0
Sodium	7.5	193.0	118.8 - 193.0
Aluminum	113.9	11.0	11.0 - 52.2

a — "As is" basis.
b — Peterson, R.F. 1965. "Wheat — Botany, Cultivation and Utilization." Interscience Publishers, Inc. New York.
c — Based on the range of 0 to 40% sorghum flour added.

[1] Graduate Student and Professor

Color is an important attribute of the finished product. In the modified Dominican hearth bread, "pan de agua," it was evident that as the percentage of sorghum flour increased in the wheat/sorghum blend, the color of the bread darkened, and the consistency became heavier. Bread prepared with 30 percent sorghum flour and 70 percent wheat flour was most preferred except color was slightly dark (Table 3). This indicates that sorghum flour can be used to substitute for wheat flour in the preparation of a baked product in the countries that do not grow wheat such as the Dominican Republic by using their locally grown sorghum crop.

Table 3. Preference of 'pan de agua' bread[a].

Preference	Color	Flavor	Texture	Overall Acceptability
Most Preferred	10	30	30	30
	20	0	40	20,40
	0	20,40	20	0
	30	10	0	10
Least Preferred	40	—	10	—

a — Number represents percent of sorghum flour added and illustrates how the panelists rank their preference.

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Hatch Act Centennial
1887-1987